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29 MARCH 1984

USSR REPORT

EARTH SCIENCES

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MEASURES TO IMPROVE ANTI-HAIL SERVICE

Moscow PRAVDA in Russian 5 Oct 83 p 3

[Article by Yu. Sedunov, First Deputy Chairman of the USSR State Committee for Hydrometeorology and Environmental Monitoring: "Batteries Against Hail--Man and Nature"]

[Text] Last summer, newspapers and television reported on heavy hail damage in Transcaucasia and Moldavia, and the heavy losses suffered by agriculture. Meanwhile, scientists had been developing means for combatting hail storms and an anti-hail service is functioning in the country equipped with guns firing special shells and suitably equipped rockets. Why did the efforts of this service turn out to be insufficient? This was the question asked by readers P. Apyshkov from Alma-Ata, V. Dolgov from Novocheboksarsk, I. Dudinov from Batum and others.

The origin of hail is linked to the formation of especially powerful cloud systems containing enormous amounts of energy and in which tens of thousands of tons of water vapor per second can be turned into water and then into heavy particles. At high altitudes and low temperatures, these particles quickly accumulate supercooled water and can grow to several centimeters in size. When they fall with speeds of 20-30 meters per second, they damage not only crops, gardens and vineyards, but even buildings and livestock.

Scientists have had notable successes in attempts to prevent hail formation and to reduce its dimensions. On the basis of radar data, they determine the cloud structure, zones of intense precipitation and the appearance of heavy particles. If there is a high level of hail danger, it is then specified when, and in what part, of the cloud a reagent should be introduced containing silver iodide. The combustion of one gram of reagent forms up to 10^{14} nuclei for crystalline particles. These particles, by natural addition to the crystalline nuclei, collect a determined part of the moisture and more hailstones are formed which are, however, of smaller size. On the way to the ground they thaw and reach the earth as rain.

In order to realize the method proposed by the scientists, active intervention services were set up in the system of the USSR State Committee for Hydrometeorology and Environment Monitoring. They operate through agreements with the Ministries of Agriculture of the union republics. At the present time, in the RSFSR, the Ukraine, Uzbekistan, Georgia, Azerbaidzhan, Moldavia,

Tadzhikistan and Armenia, seven and one half million hectares of agricultural land are under their protection. The basic unit of the antihail service is the team which has 100,000 hectares under its supervision. It is equipped with radars and has fire points located 10-15 kilometers apart. In order to estimate the hail situation, meteorological forecasts are used, special forecasts are made and observations an aerological probes are carried out. Data is also widely used which comes from meteorological satellites. Either specially manufactured artillery shells or Oblako and Alazan' antihail rockets are used to introduce the reagent.

However it should be noted, that the scientific attainments and the practical results still do not make it possible to achieve 100% success. In the first place, it i- not always possible to affect the very powerful hail processes.

How can the effectiveness of the antihail defense be assessed? In order to do this, the present situation in the defended areas must be compared with data from previous years or with the hail damage in neighboring undefended zones. On the average, during the last five years, it was possible to reduce the hail damage area by 70-80% in comparison with the average long-term data for the corresponding area up to the establishment of the defense.

How was this result arrived at? Here a determining role most certainly have been played by economic computations comparing the expenditure for defense of the areas and the cost of protecting agricultural production. These computations are carried out on the basis of averaged statistical data and show the profitability of antihail defense for regions with frequent hail damage and those where the agricultural production has an especially high value.

Now we turn to the actual events of this year. The meteorological situation was such that, in many areas of the country, hail processes of unusual intensity with respect to scale and frequency were observed. Hail fell in areas where it is extremely rare, for example in Belorussia, the Baltic area and the central areas of Russian and Turkmenistan. Cases of very large hailstones with dimensions of up to 10 centimeters and weights of up to 300-400 grams were recorded. Individual hail storms with widths of several kilometers extended over lengths of 100 kilometers. Various degrees of damage were recorded over an area of more than 650,000 hectares, which is significantly more than in normal years.

Under these complex conditions, the active intervention services produced a considerable reduction in the intensity of the hail failing in defended areas. It is true, however, that even here the area of the damaged fields amounted to 135,000 hectares. But it should be kept in mind that these are areas in which hail processes are of the greatest frequency and the damage, if the land were left undefended, would have been considerably greater.

In addition, the rigorous meteorological conditions were a test of the capacities and dependability of the antihail services. Many of their deficiencies were revealed along with complexities of a technical character which hampered the success of the work.

Firstly, there were definite restraints upon the firing into the clouds. Although the antihail equipment used guaranteed a high level of safety (due to special treatment of explosion conditions), it is necessary that the activity be coordinated with air movement control organizations and authorizations to fire must be obtained. This is a very difficult problem because of the level of use of the air space. Areas in which firing is forbidden should also be created in populated areas. A serious problem is the organization of reliable links between the command center and the fire points. It is essential that there be interference-free radiostations which can operate reliably in storms.

The basic instrument for analysis of hail-risk clouds and for determining coordinates for zones in which it is necessary to deliver the reagent is special meteorological radar. Of our radars, the MRL-5 has shown itself to be very good. But industry has not been able to fully supply the antihail services with these units. It is necessary to use other types of radar and to adapt them for these purposes. There are also deficiencies in the work of the services themselver: incorrect detection of hail storm centers, delays in seeding the clouds and failure to carry out correctly the technical instructions.

Because of the acute situation, specialists from scientific research institutes were sent to the antihail services in order to analyze the situation and supply practical assistance. The conditions of the antihail work were examined in detail in association with officials from the Georgian SSR, Azerbaidzhan SSR and Armenian SSR. The services were reinforced with personnel, additional technical facilities were supplied and special research was begun. In association with manufacturing plants, it was possible to improve the operational supply to the services of antihail shells and rockets, of which there was an acute deficit due to the unusually large consumption of these items.

The lesson of this year is, undoubtedly, that we must take additional measures to reinforce the antihail services and to equip them with more modern technology. Of this work, we consider the most important to be the effort to improve the reliability of the radars with which we are supplied and to further modernize them for automatic cloud intervention, the organization of special link systems for antihail subunits and the creation and integration of unified Nebo and Kristall antihail rocket units. Here we need the support of many ministries and associated facilities. Our scientists, first of all the specialists of the antihail center of the High Mountain Geophysical Institute, will concentrate their efforts on searches for more effective methods for intervening in high-power hail clouds.

The work season is still not over. In many areas of our country the radar antennas are aimed at the sky and there are guns and rocket equipment with thoroughly peaceful objectives. And day and night the personnel of the antihail services keep watch. Their intensive work is making a powerful contribution to the food supply programs of the USSR.

12497
CSO: 1865/20

UDC 536.25:551.551.8:551.509.6

DYNAMICS OF FREELY ASCENDING CONVECTIVE JETS INITIATED BY ACTIVE ADMIXTURE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 19, No 9, Sep 83 (manuscript received 9 Jul 81, after revision 21 Dec 81)
pp 987-988

INGEL', L. Kh., Institute of Experimental Meteorology

[Abstract] An analytical study was made of the nonlinear dynamics of convective turbulent jets over isolated stationary sources of a weightless heat-releasing admixture. This problem is examined in connection with the proposal for artificial modification of some atmospheric processes by means of an admixture (coal dust, soot) absorbing solar radiation. Use was made of the model proposed by Morton, et al. The author examined the dynamics of axisymmetric and plane jets with neutral and stable stratification, including the case of a stratification nonuniform with altitude. In contrast to traditional problems involving convective jets, in this formulation the heat source is not stipulated but is a transportable substance which is distributed in the entire volume of the jet. In the considered problem there are power-law solutions not only with a neutral stratification, but also with a stable stratification. To a certain extent problems with sources of admixture are simpler than with stipulated heat sources (although the corresponding system of equations is more complex). As an example, the author gives an expression describing convection with a heat-releasing admixture in a stably stratified medium. It has a clear physical sense: the increase in buoyancy associated with heat release in each convective element is compensated by rising into less dense layers of the surrounding medium. A similar "regime with neutral buoyancy" is also characteristic for thermals associated with instantaneous sources of an admixture, as described in an earlier article by the author (IZV. AN SSSR: FAO), Vol 17, No 2, pp 138-145, 1981). With real values of the parameters of the problem convection of the considered type and scale should not be too strong and evidently would be inadequate for effective stimulation of development of cumulonimbus clouds. References: 2 Russian. [25-5303]

UDC 551.511.6:551.510.53

MEASUREMENTS OF COEFFICIENT OF TURBULENT DIFFUSION IN MIDDLE-LATITUDE STRATO- AND MESOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 10, Oct 83 (manuscript received 18 May 82) pp 1089-1091

GARBUZENKO, V. F., SURKOV, V. T. and KHANAN'YAN, A. A., Institute of Experimental Meteorology

[Abstract] Ten experiments with artificial smoke clouds were carried out for investigating small-scale turbulence in the middle-latitude stratomesosphere. Two of these experiments were in September 1978 and three in August 1979; five others were in September 1980. The ejection of these clouds into the atmosphere was with special vaporizers carried aboard a meteorological rocket. The initial product for forming the clouds was mixtures of TXT/H_2O and TMA/TEA. The launchings were made at evening and morning twilight with angles of solar depression 2-3° when the cloud illuminated by the direct rays of the sun stood out clearly against the background of the twilight sky. The clouds formed at the heights of the strato- and mesosphere were photographed from ground observation points. The ejection of the cloud occurred on the ascending branch of the rocket trajectory for 20-30 sec, covering the altitude range 25-60 km. After completing ejection into the atmosphere a vertical trail was left with an extent of 30-35 km and an initial diameter of 10-15 m. Later the cloud moved under the influence of the system of prevailing winds, changed form under the influence of vertical wind shears and expanded in a direction transverse to the axis under the influence of small-scale turbulence. The curves of distribution of optical density corresponding to the distribution of the concentration of matter in the cloud along the horizontal direction were determined for different moments in time. These were used in computing the dispersions of displacement of cloud particles relative to the instantaneous center of gravity. Sectors of the cloud situated at one and the same altitude were considered identical. The analysis of the images of artificial clouds obtained from spaced surface points indicated that the diffusion of the cloud in two mutually perpendicular horizontal directions within the limits of measurement error occurs with identical diffusion coefficients. During the observation time the clouds were transported 5-7 km by the mean wind and within this interval of scales the K values also remained constant. Figures 3; references: 4 Russian. [28-5303]

OCEANOGRAPHY

SYMPOSIUM ON OCEAN MONITORING HELD IN TALLINN

Tallinn SOVETSKAYA ESTONIYA in Russian 2 Oct 83 p 3

[Article: "The Great Oceans: International Cooperation"]

[Text] Scientists of various nations and continents have come together in Tallinn. The capital of Soviet Estonia has been entrusted with conducting the first international symposium of its kind, devoted to the study of the great oceans. The organizers of the symposium in the USSR: the USSR State Committee on Science and Technology, the USSR Academy of Sciences, and the USSR State Committee on Hydrometeorology and Monitoring of the Natural Environment. The symposium, "Comprehensive Global Monitoring of the Great Oceans", will be held from 3 through 8 October with the assistance of the UN Program on the Environment, the World Meteorological Organization, and the Intergovernmental Oceanographic Commission of UNESCO. Academician of the Estonian Academy of Sciences K. Rebane, who is an associate member of the USSR Academy of Sciences and the president of the ESSR Academy of Sciences, told our ETA correspondent about the forthcoming representative formum of scientists.

"Monitoring is a new word" said K. Rebane. "It has not even had time to get into the authoritative Large Soviet Encyclopedia. This term denotes observation, keeping track of changes in the environment, and of course not 'by eye' but rather with the use of the most precise methods of measurement possible. The fact that scientists are inclined to use an eminently specific term perhaps emphasizes the seriousness of their intentions to carry out an in-depth, precise, systems approach to tracking the quantitative indices of the environment, the seriousness of this approach to an important problem of environmental protection and rational use of natural resources.

"The Communist Party and the Soviet State, beginning with the Leninist decrees on the preservation of nature, have shown concern on all stages for rational use and replacement of natural resources so that they will be available in full measure, as stated in the Constitution of the USSR, not only to contemporaries, but to coming generations of Soviet people.

"Monitoring of the great oceans as part of the biosphere is an especially important problem on the earth as a whole. Water is perhaps the most vulnerable element of our environment: it is most easily polluted and most difficult to restore. And the great oceans, which only about 30 years ago had seemed

to us enormous, inexhaustible, practically immune to pollution, have nevertheless begun to show the first signs of pollution. And the first step in the battle with this pollution has been establishment of monitoring of the great oceans. A number of international agreements have been signed and are being carried out in this area, and our nation is one of the participants.

"Taking part in the Tallinn symposium are agencies of the Soviet Union, and also a number of other governments are represented on a high level. The symposium has been convened to sum up and provide assistance in solving this important global issue that involves ecological, chemical and physical aspects of the life and health of the ocean. Investigation as a whole up until now has been an area of fruitful collaboration of the scientists of various nations. For example, within the scope of the Helsinki Convention on Protection of the Waters of the Baltic Sea, the USSR has been cooperating closely with all other coastal governments. Scientists of our republic as well have made their contribution to investigation of the Baltic. Professor A. Aytsam of the Institute of Thermophysics and Electrophysics of the ESSR Academy of Sciences is in charge of work on studying the ecosystem of the Baltic Sea. Scientists are doing observations and experiments aboard the "Ayu-Dag" research ship. Professor Kh. Vel'ner from Tallinn Polytechnical Institute is studying mainly the inland waters. These two science schools are doing good work on the problem of monitoring, conservation and technology of purifying waters.

"The interaction of society with the environment, preservation of the biosphere for the good of people, has become one of the urgent problems of our times. Under the conditions of the scientific-technical revolution, the accelerated growth of industrial production, the scales and acuity of this problem have grown extraordinarily. In the final analysis, the future of mankind hinges on the solution of this global problem. It is natural that it has been at the focus of the ideological struggle, has become an integral component of international relations. Its solution is inseparably connected with the struggle for peace on our planet, for prevention of nuclear war and for disarmament. This is the very first necessary condition for keeping the environment in a state suitable for human life. For nuclear war leads to hopelessly heavy pollution of the environment, and any talks about the feasibility of limited nuclear conflict or war in which one side could be victorious are absolutely groundless. This is nothing but a propagandist trick aimed at completely uninformed people. That is why there is such an urgent world-wide movement in opposition to further proliferation of nuclear armament. I believe we have a basis for feeling optimistic: the consistent peaceful policy of our nation, all of our friends, all those who stand for peace throughout the world in the final analysis will be victorious. This is how it should be, because this is the only path that mankind can and should travel. And in such a situation when peace on earth has been guaranteed, one of the very next important problems of the environment will be the cleanliness of the great oceans. I hope that the symposium in Tallinn will make a favorable contribution to this cause."

6610
CSO: 1814/56

SOVIET SUBMERSIBLES

Moscow TASS in English 6 Oct 83

[Text] The Soviet deep-sea vehicle "Argus" has repeatedly plunged to a depth of 400 meters to study the seabed and the underwater world off the shores of Cuba, says the radiogram received here. A crew of three are now working in Matanzas harbor. The observation data obtained under the CEMA "world ocean" program are transmitted to scientists of Cuba, the USSR and Bulgaria.

In the Soviet Union, as all over the world, interest is growing in underwater mineral deposits. Deep-sea vehicles "Sever", "Tinro", "Argus" and others have been created and successfully used for prospecting for mineral deposits and for prospecting and study of commercial fish resources. The equipment has been used to make maps, in particular of the seabed of the seas of Japan and Okhotsk. Work is now being completed to compile a geological map for the whole Far Eastern shelf of the USSR.

The latest of the series of underwater craft designed by Soviet engineers is "Okeanolog", which is notable for high maneuverability and is fitted out with a manipulator imitating the movements of a human hand to take samples of sedimentary rock, cut them, place into containers rock samples weighing up to 20 kg and accurately install instruments on the seabed.

The Soviet deep-sea vehicles used for resolving economic tasks are not designed to reach record depths. The "Argus" vehicle, for example, plunges to a depth of 600 meters, while "Tinro", used for spotting fish shoals, can operate at a depth of 400 meters. But the Soviet research fleet has even more courageous divers. The craft of the "Paysis" series, for example, submerges to a depth of 2,140 meters.

CSO: 1852/2

SCIENTIFIC RESEARCH SHIPS OF 'PROFESSOR SHULEYKIN' TYPE

Moscow MORSKOY FLOT in Russian No 11, Nov 83 pp 44-46

[Article by Yu. Dundur and A. Seidbatalov]

[Text] The scientific research fleet of the USSR has been supplemented by new vessels of the "Akademik Shuleykin" type, constructed at the "Layvateollisuus" shipyards (Finland). The ships are intended for carrying out a complex of work in the field of hydrology, hydrochemistry, meteorology and monitoring of the environment.

Principal Specifications

Length:	
-- maximum	71.6 m
-- between perpendiculars	64.3 m
Width	12.8 m
Height of side	6.45 m
Maximum draught	4.5 m
Deadweight:	686.0 tons
-- gross	1753.90 registered tons
-- net	526.17 registered tons
Power of main engine	2 x 1.15 MW (1560 HP)
Speed	12 knots

The "Akademik Shuleykin" is a two-deck vessel with an elongated foredeck, is single-screw, with a stern positioning of the engine compartment, with cargo-loading facilities in the above-water part of the stern and a superstructure in the middle part of the ship.

The vessel was constructed under the supervision of the USSR Register in the class KM ⊛ UL Ⓘ A2 (research). The vessel has an unlimited sailing range.

The ship's hull is fully welded and divided by watertight bulkheads into 8 compartments; frames are incorporated near the engine compartment and in the tank compartment. The working deck is strengthened, taking into account the transport of deck cargo; the admissible load is 2 tons/m^2. The categories and types of steel used in the hull satisfy the requirements of the USSR Register for vessels constructed with strengthened ice reinforcements of the UL class and operating at an ambient temperature of -40°C.

The ship has three Hall anchors each weighing 1.5 tons (one of them a spare) and two anchor chains with a total length of 473.4 m. The letting out and raising of the anchors is with a type-B5 windlass and there are chain "stops" of the screw type. The mooring apparatus, in addition to a windlass on the foredeck, includes a capstan which is installed at the stern, 6 mooring bitts, 4 chucks with rowels.

The rescue equipment consists of two glass-plastic motor launches of the closed type holding 40 persons. The launch motors are air-cooled diesels. In addition, there are 4 inflatable rescue rafts of the PSN-10M type for 10 persons each, 12 ring buoys, 71 life jackets and a line-casting apparatus.

The ship's rudder is of the two-layer type, with a streamlined configuration, with two supports in the upper and lower parts. In order to prevent the rudder being damaged by the ice there is a special icebreaker of durable construction installed behind the rudder at the rear. The rudder apparatus is electrohydraulic with two pumps. The power of each pump ensures the shifting of the rudder from side to side in 28 sec when proceeding at full speed. Provision is made for the operation of both pumps simultaneously, which ensures shifting of the rudder from side to side in 20 sec.

In order to improve control of the ship at a speed less than 7 knots the vessel is outfitted with a rotary rudder. At the front of the rudder blade, along its entire length, there is a rotor operating at 800 rpm. At the ship's prow there is a rudder control apparatus designed by the "Yastram" Company with a power of about 150 KW. In order to lessen the ship's pitching and improving working conditions at sea during wave action the vessel has two damping tanks. The "Intering" system ensures automatic regulation of the period of liquid flow into the damping tanks, depending on the period of the ship's pitching.

The living and service quarters are situated at midships. There are three sets of cabins -- 13 1-man cabins with bathrooms, 2 1-man cabins and 24 2-man cabins. In addition to the wardroom and dining room, for the rest and recreation of the ship's company and officers the ship has a reading and recreation room, a photographic laboratory and a sauna. The following laboratories are present on the ship for carrying out scientific research work:
-- meteorological, outfitted with a station, which ensures the automatic collection and processing of all the data arriving from the meteorological sensors;
-- aerological, in which there is a station ensuring automatic collection and processing of information arriving from the upper layers of the atmosphere from a radiosonde;
-- oceanographic (wet) -- a room for bathometers with equipment for the primary processing of water samples;
-- oceanographic (dry) -- a laboratory with a bathometer-probe complex intended for the automatic measurement of water parameters at different horizons; this apparatus also makes it possible to take water samples.

In addition, there are hydrochemical and biological laboratories and a laboratory for the collection and processing of information.

The ship carries a computation system which includes electronic computers installed in the laboratories, automatic and semiautomatic measurement complexes

and laboratory analyzers. These elements are interconnected with one another in such a way that together they create an automated system for the collection, processing and storage of hydrometeorological information.

For the purposes of carrying out hydrological research work the deck equipment includes an electrohydraulic crane at the stern with a load-lifting capacity of 5 tons with a boom reach of 12.5 m, a crane at the prow with a load-lifting capacity of 2 tons with a boom reach of 8.5 m and 7 winches having cable storage lockers and with an adjustable pitch for cables of different diameter, as well as counters for measuring the length of cable which has been let out. In the neighborhood of the winches there are crane beams or π-shaped frames with a hydraulic drive.

The ship's main engines are 2 Soviet-produced diesels of the 6URN 36/45 [G 74] type. The main engines are 6-cylinder 4-stroke nonreversing diesels with supercharging. The engines operate on diesel fuel. Each main engine is connected to the common reducer of an elastic disengaging clutch. A thrust bearing is built into the reducer. There is a power takeoff from the reducer for the shaft generator. In the event of an overload, such as under icy conditions, the disengaging clutches are activated automatically. The mechanical apparatus is supplied with an automatic system preventing the engaging of the main engines and the shafts when there are different rates of rotation.

The power drive train consists of two intermediate shafts and a screw shaft with a continuous bronze facing along the entire length of the deadwood pipe. The deadwood pipe is steel; the setting for the bushing is rubber-metal with water priming. The screw of adjustable pitch of special bronze, of the four-blade type, was fabricated by the "KaMeVa" company.

The control of the screw apparatus is from the wheelhouse, where there are 3 control posts, and also from the central control post.

The shipboard electric power station consists of three DGR 150/750 diesel generators of the 6ChN 18/22 type, each with a power of 160 KW (225 HP) with 750 rpm. The voltage of the generators is 400 V. The emergency source of electric power is a DGA 50-9R diesel generator with a power of 50 KW (80 HP) with 1500 rpm. The shaft generator, produced by the "Stromberg" company, has a power of 268 KW.

The boiler plant consists of a combined boiler with a steam output of 1,000 kg/hour (operating on diesel fuel) or 300 kg/hour (operating on exhaust gases). In order to meet the needs for compressed air there are 2 compressors (one in reserve) with a delivery of 45 m^3/hour, operating automatically.

The refrigeration plant for the food lockers is serviced by two compressors. The system for air conditioning of the living and working areas consists of air conditioners and two compressors.

For the supply of the ship with fresh water there is a freshening plant of the D4U type with a delivery of 10 m^3/day. For the processing of this water there is a bactericidal filter, mineralization and aeration system.

For the separation of fuel and oil there are two separators of the MARKh-204 type, each with a delivery of 2 m^3/hour, and for the purification of fuel-contaminated water -- a separator with a delivery of 1 m^3/hour. The contaminated water is collected in a tank with a capacity of 4.67 m^3, whereas sewage water is collected into two tanks each holding 9.77 m^3. The sewage water is processed by an apparatus with a rated capacity of 21 m^3/day. An incinerator is used for the burning of waste.

The volume of automation on the scientific research ship "Akademik Shuleykin" makes it possible to service the main power plant during movement by one watch mechanic from the central control post and without standing of a watch at the central control post and in the engine compartment when anchored.

The monitoring of work of the entire power complex is from the central control post by the system for emergency-precautionary signaling. In addition, it notifies the captain's watch assistant on the bridge on the state of the power plant. The ship also has a system for emergency-precautionary signaling for the watch mechanic. It signals about those malfunctions in the emergency-precautionary signaling system which have two levels of urgency -- critical and subcritical.

The ship is outfitted with all modern means of radio communication and electrical radionavigation, including a satellite navigation system receiver.

5303
CSO: 1865/30

SEISMOLOGICAL MEASUREMENTS ON OCEAN FLOOR

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 83 pp 17-21

[Article by S. L. Solov'yev, corresponding member, USSR Academy of Sciences]

[Text] What means are used in studying seismic tremors occurring beneath the layers of the world ocean? This article tells about the development of different methods used for the registry of such tremors both in our country and abroad.

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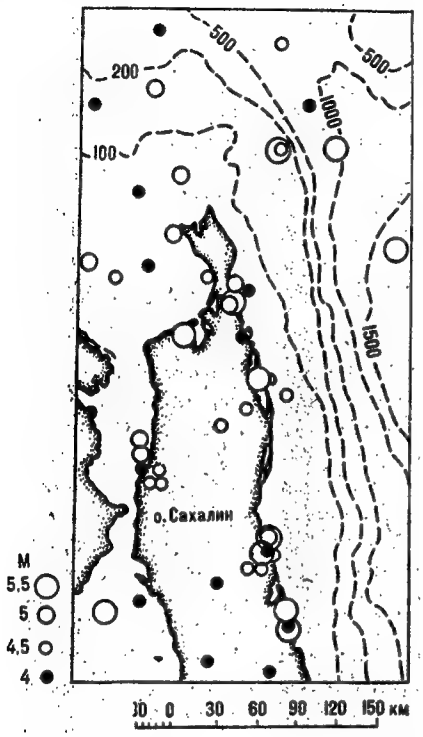
Earthquake Foci on Ocean Floor

A total of 85% of all earthquake foci are hidden beneath the waters of oceans and seas. Accordingly, it would seem that seismology should be predominantly a marine science. However, for the time being it continues to remain a land science. Investigations relying on bottom observations constitute several percent of all seismological work. However, marine seismology is gaining strength. Several main directions can be noted in this work, including, for example, study of the internal structure of the earth, the causes of the seismic process and its laws, its relationship to the general evolution of the earth and prediction of seismicity. Not for a single one of these directions is it possible to achieve success without carrying out long-term observations in the seas and oceans. We will cite two examples.

The first is related to the study of the earth. According to the theory of lithospheric plates, along the margins of the Pacific Ocean there is a thrusting of the oceanic lithosphere beneath the continental lithosphere. Seismologists for the first time discovered zones of underthrusting in the form of thin but extensive (hundreds and thousands of kilometers) layers extending beneath the island arcs and sometimes also under the continents to a depth as great as 700 km. The seismic foci are concentrated in these. The internal structure of these seismic focus layers for the time being is poorly known due to errors in determining the hypocenters of earthquakes: they attain 30 km, and this is the approximate thickness of the seismic focal layer. In the theory of underthrusting developed at the Institute of Oceanology, USSR Academy of Sciences, there is prediction of definite surfaces of deformations beneath the slope of an abyssal trench, to which, in all probability, the seismic foci are also associated. A rare case in seismotectonics when theory outpaces observations! But here checking is required and it is impossible without the installation of a

system of bottom seismographs on this slope for a prolonged time. The implementation of such a complex and costly experiment is not solely of purely scientific interest -- checking the theory of the earth's evolution. Without this it is simply inconceivable to construct a reliable seismotectonic map of the Kurile-Kamchatka zone, necessary for practical needs, for example, tsunami regionalization of the Pacific Ocean shores of the USSR.



Location of earthquake foci registered in northern Sakhalin and near it during the last 50 years. More than half of the foci are hidden beneath the water layer. Foci with different magnitudes are represented by circles of different sizes.

The second example is related to the seismic regionalization of the shelf in our country, where the production of petroleum and gas is beginning. Several industrial deposits are being prepared for exploitation on the northeastern shelf of Sakhalin and during the last 50 years 8 earthquakes have been registered there which were stronger than the Tashkent earthquake of 1966. It is clear that the construction of complex, expensive structures, dangerous for the ecology of the Sea of Okhotsk, must be preceded by a detailed seismic investigation of the shelf.

Registry of Underwater Earthquakes

Radio buoys outfitted with hydrophones are intensively used in our country and abroad for seismic prospecting work at sea. Sporadically they are also employed for the registry of microtremors. For example, in 1967, on a voyage of the "Akademik Kurchatov" in the Indian Ocean, an anchored buoy station in four days registered about 500 microtremors. During 1972-1974 American researchers used anchored buoys more than 10 times, but for the most part drifting buoys for the registry of swarms of microtremors and the subsequent tremors of strong earthquakes, including use of buoys developed for the detection of submarines. In our country an array of radio buoys for seismological observations was developed at the Special Design Bureau of the Sakhalin Multidiscipline Scientific Research Institute of the Far Eastern Scientific Center, USSR Academy of Sciences (Sakhalin KNII).

Earthquakes are also registered by underwater cable systems outfitted with hydrophones and seismic detectors. Such work was initiated in the United States immediately after the Second World War. Experimental apparatuses were installed in the Atlantic on Bermuda and Antigua, in the Pacific at stations situated on the atolls in the central part of the ocean, on the Hawaiian Islands and in California.

A bottom cable hydrophysical station, which operated for more than six years, was laid out in May 1966 at a distance of 200 km from San Francisco at a depth of 3,900 m by the Lamont Geological Observatory.

In the Soviet Union experiments for the registry of earthquakes by underwater cable systems were carried out at the "Shikotan" Hydrophysical Observatory, organized by the Sakhalin KNII in the early 1960's. An interesting cable system is being created by the Japanese, especially for the prediction of a strong earthquake in the Tokio region. Five underwater coaxial cables with a length up to 100-400 km were laid from the eastern coast of the country. Each of these held up to six intermediate three-component seismometers with a frequency band 2-20 Hz and one lower-frequency terminal seismometer, matched with a tsunami recorder. This cable system has not yet been finished, but the first line -- to the southwest of Tokio -- was put into operation in 1978.

Self-Contained Bottom Stations

The first attempts at observations with self-contained bottom seismic stations were undertaken in the United States, Japan and USSR long ago, but for various reasons these were not further developed. An important incentive for such work was provided by the problem of detection of underground nuclear shots. In 1960 the United States Department of Defense, in the "Vela-Uniform" project, allocated considerable sums for clarifying to what extent the ocean floor is preferable for the placement of stations for detecting shots. As a result, about 10 different apparatuses were created by means of which observations were made in the Pacific, Atlantic and Arctic Oceans. To be sure, these apparatuses were not perfect but many innovations are still of interest. For example, for the first time there was telemetric transmission of information through a hydroacoustic channel.

The "swan song" of the "Vela-Uniform" project was the Kurile experiment (costing $900,000) in 1966 when it was possible to carry out 10 observations with a duration from five days to a month in the abyssal trench along the southern part of the Kurile Ridge. The results of the American observations were processed primarily at the Sakhalin KNII and this made it possible to construct a model of the seismic focus layer differing from that existing earlier.

Measurements on the floor of different oceans and seas demonstrated that there the noise level and signal-to-noise ratio are approximately the same as on the land. Thereafter the financing of experiments of this type was cut off and work in the field of marine seismology in the United States almost completely ceased.

In the mid-1960's specialists at Moscow State University imeni M. V. Lomonosov, under the direction of Professor L. N. Rykunov, created a bottom seismograph consisting of a cylindrical instrument capsule, anchor, Kapron connecting line and a surface signaling buoy. The instrument was quickly "taken over" by specialists in the field of deep seismic sounding at the institutes of the USSR Academy of Sciences. During the years which have elapsed, to be sure, there has been a change in instrument details but the principle of the submersible system and the receiving-recording channel has been retained. Different variants of

this instrument are now being used. The receiving-recording channel of this station consists of seismic reconnaissance sensors on a Cardan joint, low-noise input stage, power amplifier, spool or cassette tape-moving mechanism, time unit and power source.

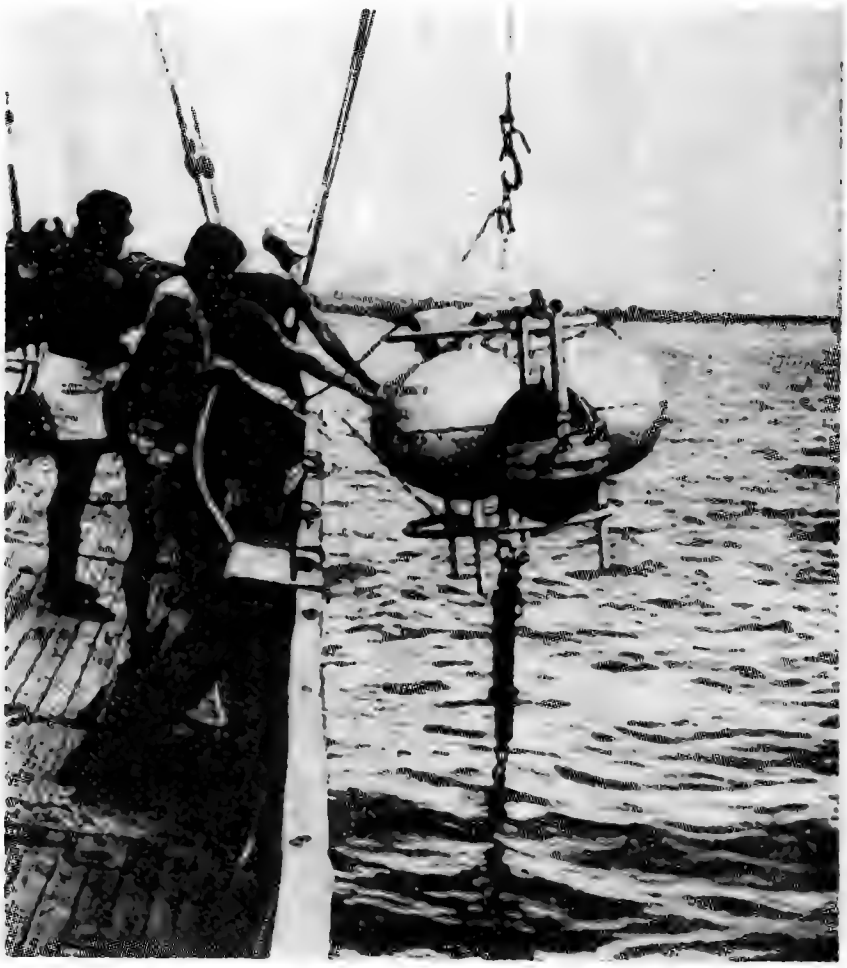
The registry of earthquakes in the ocean by stations of the underwater type has usually been carried out in the USSR coincidentally with deep seismic sounding. A series of valuable results were obtained, for example, an expedition of the Institute of Oceanology, USSR Academy of Sciences, in 1977 discovered a high seismicity of the Hess Basin in the neighborhood of the Galapagos. However, there have not been so many special experiments on the ocean floor during the last 15 years in the USSR. These experiments included the registry of microtremors in the Vityaz' trench in the Arabian Sea-Indian Ocean Ridge during 1967 and 1972, work carried out by a group from Moscow State University; a joint experiment of the Sakhalin KNII and the Institute of Physics of the Earth, USSR Academy of Sciences, in 1975 for the registry of earthquakes to the east of Iturup Island on the underwater Vityaz' plateau; work by Moscow State University in 1980 in the Atlantic in the Vema fault of the Mid-Atlantic Ridge; a joint experiment of Moscow State University and the Institute of Volcanology, USSR Academy of Sciences, in 1981 for registry of earthquakes at the juncture of the Kurile-Kamchatka and Aleutian trenches; observations of specialists of the Institute of Oceanology, USSR Academy of Sciences, in this same region in 1982.

In Japan much attention is being devoted to bottom seismometry and seismology. In the 1960's and 1970's specialists at the Earthquake Study Institute at Tokio University developed about 10 designs of bottom seismographs, first heavy bottom-buoy variants and then those which floated up by themselves. They carried out about 20 seismological observations in the ocean, but study of the seismicity of the ocean slope of the abyssal Honshu trench was of particular interest. This trench was found to be seismically more active than followed from observations made at island stations.

In the late 1960's the bottom seismograph of the Moscow State University system was borrowed by another group of Japanese specialists and was in use until recently. On the ocean floor the seismograph instrument capsule sank deep into the unconsolidated bottom material. As a result, there was a decrease in the induced noise and it was possible to register weak signals from great distances. Similar instruments during 1973-1980 made it possible to carry out observations in the Pacific Ocean on six long profiles (up to 1,700 km), at whose ends earthquakes were registered or artificial shots were set off. As a result it was possible to obtain "velocity" sections of the earth's upper mantle to a depth below 60 km and a hypothesis of strong anisotropy of the earth's upper mantle was advanced on the basis of the detected difference in the velocities of elastic waves in meridional and latitudinal directions.

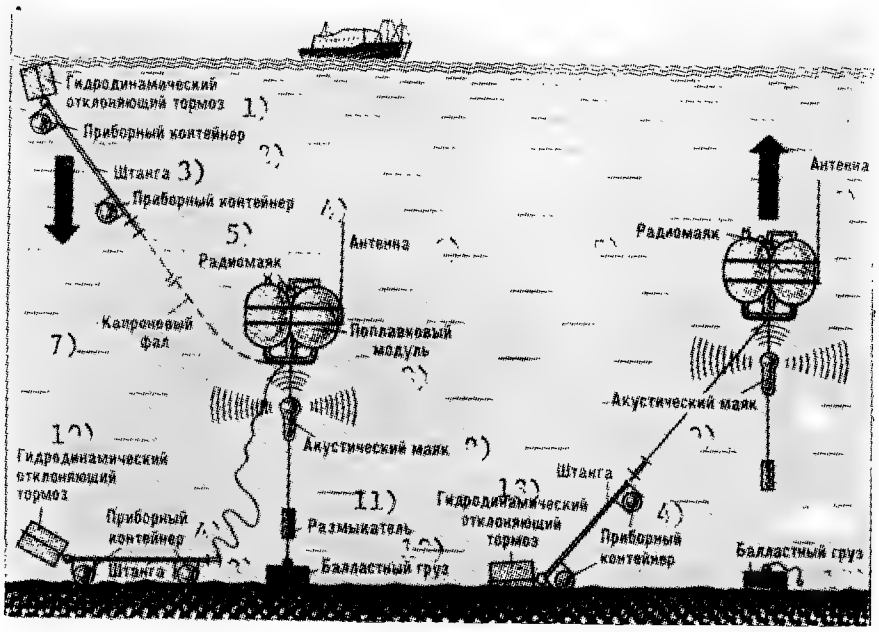
The achievements of Soviet and Japanese specialists and the vigorous development of the tectonics of lithospheric plates, requiring the checking of fundamental hypotheses by experiments with high-response seismographs, provided a new stimulus for the development of bottom seismology in other countries as well. Designs of abyssal self-surfacing bottom seismographs were created, first in Great Britain, and then in the United States and Canada. The designing of

the self-contained stations was accomplished in different ways. In some use was made of spherical instrument capsules with a diameter of 60-70 cm having good buoyancy; in others use was made of cylindrical capsules oriented horizontally or vertically.



Lowering of MADS-6 station. Gelendzhik, 1980.

The capsules were fabricated primarily of aluminum alloys, which ensured a depth of submergence up to 6,000 m. Having a plated, and for protective purposes, a well-painted surface, they are capable of withstanding corrosion and can be underwater in a working state a full year. As ballast for the instrument use is made of separable steel supports in the form of plates, a tripod, sometimes with sharpened legs or with collars weighted with lead, and sometimes concrete, pig iron or lead. In order for the surfaced station to be located more easily it is usually supplied with a pinging beacon, radio beacon and flasher; in addition, it is painted with a fluorescent paint, is equipped with a bright flag and corner reflector.



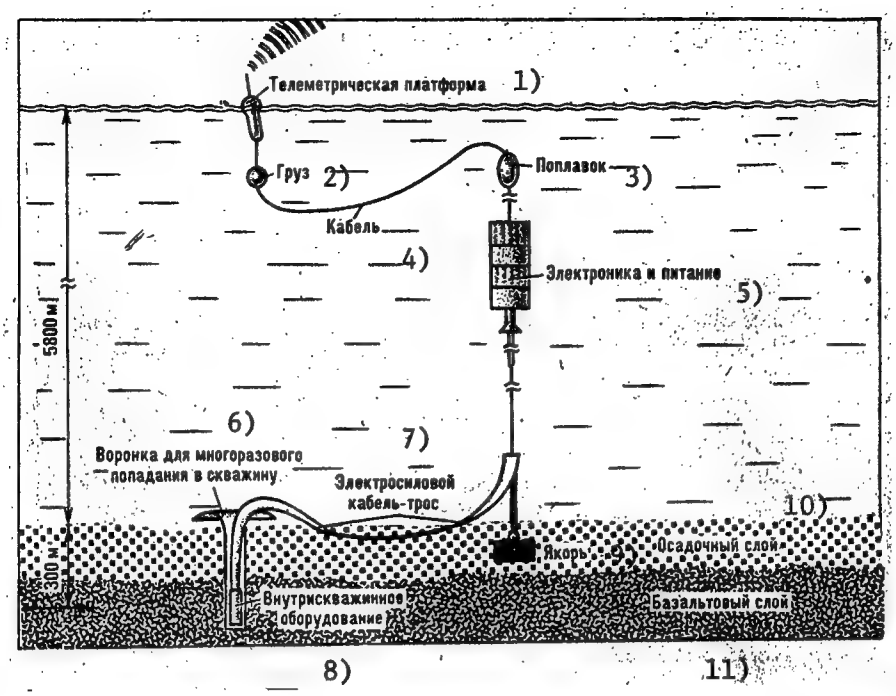
Process of operation of MADS-6 station. The station is lowered to the bottom. First it reaches the weight with the float, then the rod with the instrument capsules. During surfacing of the station the float module is accelerated and then the rod with the instrument capsule is detached from the bottom by the connecting line.

KEY:

1. Hydrodynamic deflecting brake
2. Instrument capsule
3. Rod
4. Instrument capsule
5. Radio beacon
6. Antenna
7. Kapron line
8. Float module
9. Acoustic beacon
10. Hydrodynamic deflecting brake
11. Release
12. Ballast weight

The method used in the registry of seismic phenomena at the self-contained stations is magnetic recording (attempts at registry on motion picture film have not been successful). More than half such stations use direct analog registry, yielding the greatest volume of information.

The imperfection of the described self-contained bottom seismic stations, their costliness and unwieldiness made it impossible for any of these variants to come into wide use; each of them was fabricated in a few copies. It is true that they have performed some useful service. Using these outfits during 1972-1980 it was possible to carry out several experiments in the mid-oceanic ridges in the Atlantic, Pacific and Indian Oceans. And although there were no further determinations of the site and level of seismicity, it was possible to draw conclusions concerning the great seismicity of major transverse faults in the earth's crust in comparison with rift valleys.



One of the variants of operation of a submersible seismic detector installed in borehole in ocean floor drilled from ship "Glomar Challenger." Seismological data are fed along a cable to an electronics block and then are sent to a telemetric platform. From there the information is sent to an artificial earth satellite.

KEY:

1. Telemetric platform
2. Weight
3. Float
4. Cable
5. Electronics block and power unit
6. Funnel for repeated entry into borehole
7. Electrical and supporting cable
8. Intraborehole equipment
9. Anchor
10. Sedimentary layer
11. Basalt layer

Stations of New Generation

A qualitative jump occurred in the late 1970's when the American "Benthos" Corporation began to turn out light and relatively inexpensive deep-water capsules consisting of two joined hemispheres of a special borosilicate glass. The entire station with this capsule weighs 60-70 kg; the returnable capsule with instrumentation -- a total of 30-40 kg. Such instruments were first fabricated and used at Texas State University (United States) and Tokio and Hokkaido Universities (Japan), but not in a few copies, but in the dozens. Experiments with these instruments were used in the zones of the island arcs, where seismicity is at the highest level.

Taking into account the new requirements on the formulation of experiments in the USSR and abroad, submersible systems with a remote seismic detector were

created. The interesting MADS-6 submersible system was developed at the Institute of Oceanology, USSR Academy of Sciences. It includes a rod with two ellipsoidal instrument capsules and a carrier consisting of a frame, a float module - spherical plate, hydroacoustic release, ballast and detection unit. Submerging, the station creates a hydrodynamic flow displacing the rod from the carrier and due to a deflecting "wing" carrying it to one side the length of the connecting line. During the surfacing of the station the float module is first accelerated and this in a jerk detaches the capsule from the bottom or yanks it from the unconsolidated sediments. Tests of the station were made at Gelendzhik in 1980 and 1981 from aboard a ship and with use of the "Argus" manned submersible also in the Pacific Ocean in 1981-1982.

The first system of seismometers completely submerged beneath the bottom level (they are placed in boreholes in the sea floor) was created on the California shelf in the Santa Barbara Channel at a depth of 100 m. It is used for monitoring the "seismic life" of a petroleum-producing region. Five seismometers are buried in the sediments to a depth of 2-5 m. Signals from these seismometers are fed to one of the drilling platforms and from there to the on-shore processing center.

The concept of submersible seismic detectors is made clear most fully in a special project of the United States Department of Defense in which observations are made in deep boreholes, in the hundreds drilled in the floor of the world ocean from the ship "Glomar Challenger." The seismic detectors installed in the boreholes should operate continuously for several years. A system with neutral buoyancy is placed in the water layer; signals from the detector are fed to this system and processed there. Useful information is transmitted at stipulated times via a surface radio buoy and via space communication channels is sent to a central point on the land.

Perspectives

During the last several years new trends have appeared in the development of seismological work at sea. Now use is made primarily of relatively inexpensive capsules of borosilicate glass instead of costly capsules of aluminum alloys. Accordingly, it has become realistic to change from observations at individual points (one - three bottom stations) to observations over great areas of the floor (deployment of 10 stations). It is the immediate task of marine seismology to create self-contained bottom stations with a remote (folding) block of seismic detectors with its placement in boreholes drilled in the ocean floor and also to increase the independent lifetime of the station to several months or an entire year. Now professional seismologists have begun to be interested not so much in rift structures situated in the relatively weakly seismic mid-oceanic ridges as in the highly seismic subduction zones where lithospheric plates interact intensively. These zones are situated primarily along the margins of the Pacific Ocean. In addition, now great attention is being devoted to measurements of acceleration of the sea floor during strong earthquakes because this is necessary for the designing of sea drilling platforms.

The author of this article feels that an immediate objective of marine seismology in our country could be a major Kurile-Kamchatka experiment with the

deployment of the maximum possible number of bottom seismographs over a great area, primarily on the island slope of an abyssal trench. The extent of the trench in the boundary waters of the USSR is 1,800 km and the width of the seismically active zone is about 180 km. With adherence to a reasonable distance between stations of 30-40 km such an experiment would require about 300 simultaneously operating bottom stations. For the time being this is unrealistic at a full scale but an experiment with coverage of half the zone could be carried out in the next few years. Without question it would provide fundamentally new and important material and could become the first major landmark in the modern stage of seismological investigations at sea.

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LEADER OF 6TH CRUISE OF 'AKADEMIK MSTISLAV KELDYSH' INTERVIEWED ON ACOUSTIC RESEARCH

Moscow VODNYY TRANSPORT in Russian 12 Jan 84 p 4

[Interview with Yuriy Yur'yevich Zhitkovskiy, professor, doctor of physical and mathematical sciences, by A. Kosobrodov, VODNYY TRANSPORT correspondent, "By Acoustic Methods"]

[Text] The sixth expeditionary cruise of the scientific research ship "Akademik Mstislav Keldysh," belonging to the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, was not altogether usual. The fact is that it was virtually completely devoted to investigation of the ocean by new noncontact methods. The scientific director of the expedition was Academician Leonid Maksimovich Brekhovskikh, secretary of the Division of Oceanology, Atmospheric Physics and Geography, recipient of the Lenin and State Prizes. The expedition's work was done in the Atlantic and Pacific Oceans.

Our correspondent turned to the head of this expedition, Professor Yuriy Yur'yevich Zhitkovskiy, doctor of physical and mathematical sciences, recipient of the USSR State Prize, with a request to answer several questions.

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[Question] Yuriy Yur'yevich, it is known that this cruise was somewhat unusual for your institute because the ocean was investigated using new methods, for the most part acoustic. Could you not tell in somewhat greater detail exactly why acoustic methods were employed?

[Answer] Usually we collect information by means of electromagnetic waves, be they in the visible or radio range. Unfortunately, electromagnetic waves experience great attenuation in saline sea water, which is a good conductor of electricity. Because of this man can see only several tens of meters into the ocean and only then when the illumination is good. And it is virtually impossible to use radar and radio communication under the water.

However, there is one type of waves which propagate in water far better than in the air -- acoustic waves. Thus, today acoustic waves in water are our only substitute for electromagnetic waves. This substitution, to be sure, is not exactly the same, if for no other reason than that the velocity of their propagation in the water is almost a million times slower than the propagation of electromagnetic waves in the air. In addition, the laws of propagation of acoustic waves in the ocean are greatly complicated by the inhomogeneity of water masses and

the presence of two boundaries -- surface and bottom. The upper boundary is virtually opaque for acoustic waves, it is almost always uneven and its form changes with time. The lower boundary does not change with time, but it is not only uneven, but also inhomogeneous. Moreover, it is partially transparent for acoustic waves, which penetrate to the ocean floor.

The reception of weak signals is complicated by the presence of a surrounding background which consists of noise caused by dynamic processes, for the most part wind waves, biological noise (it is well known that marine animals make extremely broad use of acoustic waves), seismic noise, noise of passing ships, etc.

Even from such a brief enumeration of the factors exerting an appreciable influence on the propagation of acoustic waves in the ocean one can see all the complexity of the process and it is possible to imagine the difficulties which are encountered in its investigation. A new science, which is called ocean acoustics, is concerned with all these matters.

However, the study of acoustic fields in the ocean is only a part of the problems which we are studying. There are those problems which are usually called inverse problems. With respect to the nature of propagation, reflection and scattering of acoustic waves it is possible to obtain information on the properties of the medium and also on the reflecting and scattering objects. A determination of the characteristics of the ocean on the basis of such information is the final objective of these investigations.

[Question] Now, Yuriy Yur'yevich, I would like to hear about your expedition, devoted to study of the ocean by acoustic methods. Please tell about the expedition, its tasks and results.

[Answer] The program for our expedition provided for solution of several problems: study of the characteristics of the wave-covered ocean surface by means of acoustic waves scattered by the surface in the opposite direction; investigation of bottom layer surface structure by means of acoustic waves reflected and scattered by the bottom; investigation of biological productivity of the ocean by means of acoustic waves scattered by sea organisms; study of dynamic processes in the ocean by means of investigation of its dynamic noise.

A highly important task of the cruise was a determination of the possibility of speedy exploration of ferromanganese nodules by the acoustic method, that is, by means of acoustic signals scattered by nodules lying on the bottom surface. It was confirmed that it is possible to determine the presence of nodules on the floor by the acoustic method. It was found that it is feasible to make a survey while the ship is proceeding on course with a high productivity.

Computers were used very extensively on this expedition. In addition to the large standard shipboard computer there were many specialized computers making it possible to carry out preliminary processing of the results.

We should evidently also say that the ship carried 65 crew members and 60 scientific specialists from different institutes of the USSR Academy of Sciences at places ranging from Moscow to Sakhalin. In addition, this number included a group of students from the Moscow Physicotechnical Institute.

[Question] Your expedition included a group of specialists from the State Standard All-Union Scientific Research Institute of Physicotechnical and Radiotechnical Measurements. What role did they play in the expedition? What is the role of metrology in oceanology?

[Answer] It should be noted that we devoted very great attention to such work on our expedition and much time was allocated to its implementation. Control checking of the instrumentation was carried out before and after each experiment. In addition, during calm weather detailed calibrations were carried out and directional diagrams of all the employed sound sources and detectors were also plotted. This work took us several days.

It is evident that metrological support is the foundation on which the reliability of the experimental material is based, as well as the comparability of data obtained by different researchers, the possibility of carrying out generalizations on the basis of the results obtained at different times and in different regions by different expeditions. Unfortunately, in many cases not as much attention is devoted to calibration work during research as is necessary. Leaving aside the problems of metrological support, I can say that in almost all the investigations in the field of ocean acoustics which we are carrying out use is being made of "home-made" instrumentation. Each institute fabricates instrumentation for its own use.

You could object that ocean acoustics is a young science. Indeed, it has not been in existence for much more than 20 years. But whereas this is too little for answering all the demands which can be placed on it, it is entirely adequate for its supply with the most elementary instruments.

[Question] Now the traditional question: what are the prospects for developing new methods for investigating the ocean? What awaits us in the future?

[Answer] What is to be expected in the future? Even today we have ideas as to how it is possible virtuously continuously to obtain this information concerning the characteristics of the world ocean over its entire surface. This method has been given the name "acoustic topography." Its essence is as follows: if several receiving and radiating systems are emplaced quite rigorously along the perimeter of an ocean region whose characteristics must be known, and then acoustic pulses are alternately emitted and received, the time of signal propagation will carry information on the medium through which they are propagated, that is, on the region of the ocean encompassed by the receiving-emitting systems. As a result adequate information will be obtained which will enable us to learn the characteristics of the ocean medium. Of course, there are many difficulties. First of all, the problem must be solved theoretically; second, it is necessary to set out a great number of adequately powerful emitting systems over the entire area of the world ocean and monitor their radiation. Third, it is necessary to create a supply of powerful computers which in a relatively short time could process an enormous volume of information. And much, much else ...

In addition to solution of this problem, ocean acoustics should assist in creating highly accurate acoustic navigation systems and developing completely new methods for investigating the ocean which at present we cannot even visualize.

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VOYAGES OF SOVIET SCIENTIFIC SHIPS (JANUARY-JUNE 1983)

Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 83 pp 39-41

[Article by A. A. Goncharenko]

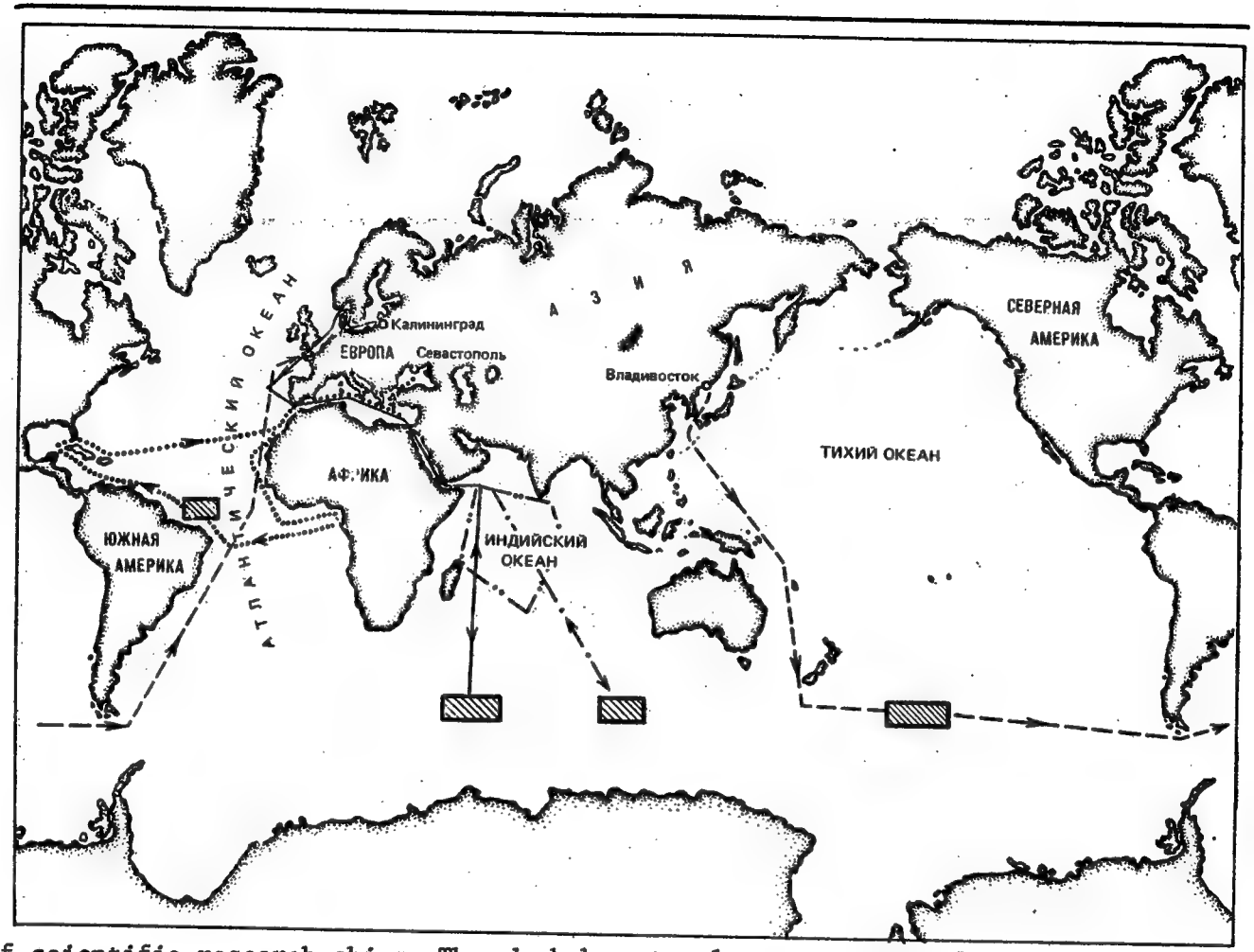
[Text] An expedition in Antarctic waters on three ships of the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, the "Akademik Mstislav Keldysh," "Vityaz'" and "Dmitriy Mendeleyev," ended in early April. The first vessel made investigations in the Atlantic, the second in the Indian Ocean and the third in the Pacific sectors of Antarctica. Studies were made of the spatial and deep structure of the Antarctic Circumpolar Current (encircling the southern continent) and the Antarctic Polar Front; the energy exchange between the ocean and atmosphere in this region was evaluated. Incidentally biological investigations were made en route; these dealt with the resources of exploitable fish in the Antarctic Ocean.

The ship "Akademik Mstislav Keldysh" made its regular voyage in the central part of the Atlantic and in the eastern part of the Pacific Ocean, where a study was made of the correlation between the acoustic fields in different regions of the World Ocean, hydrometeorological conditions and bottom characteristics.

The first Soviet oceanographic expedition on the ship "Professor Shtokman" (Institute of Oceanology, USSR Academy of Sciences) operated in the basin of the Amazon River and on the Brazilian shelf, making geological, biological and biogeochemical investigations (see article in this number of the journal). Then the "Professor Shtokman" headed for the Barents Sea. On the new voyage studies were made of the sedimentary layer, lithodynamic processes and gas-biochemical fields of the bottom medium.

An expedition on the ships "Akademik Kurchatov" and "Rift" (Institute of Oceanology, USSR Academy of Sciences) was carried out in the Indian Ocean within the framework of an integrated multidiscipline biological program. Scientists attempted to understand how the increased bioproductivity of individual underwater rises, ridges and banks is formed.

Investigations of ecosystems, evaluation of their productivity, determination of biological resources and clarification of the prospects for their use were the objectives of an expedition in the Indian Ocean aboard the ship "Professor Vodyanitskiy" (Institute of Biology of the Southern Seas, USSR Academy of



Tracks of scientific research ships. The shaded rectangles represent polygons where investigations were made

_____ "Akademik Mstislav Keldysh"
_ _ _ _ _ "Dmitriy Mendeleyev"
_.._ "Akademik Kurchatov"
_._._._ "Vityaz'"
....."Akademik Vernadskiy"

Sciences). An expedition on the ship "Professor Bogorov" (Far Eastern Scientific Center, USSR Academy of Sciences) also operated in the Indian Ocean. Observations of marine organisms in the tropical regions of the World Ocean initiated by the Pacific Ocean Institute of Bioorganic Chemistry, Far Eastern Scientific Center, USSR Academy of Sciences, were continued.

In the Bay of Bengal work was done by the scientific research ships "Pegas" and "Morskoy Geofizik" (Far Eastern Scientific Center, USSR Academy of Sciences). Multidiscipline geological-geophysical work was done here in polygons and studies were made of the structure and composition of geological formations, the correlation between the heat flow and mineralization fields.

Specialists aboard the ship "Dal'niye Zelentsy" carried out an expedition of the Murmansk Marine Biological Institute, USSR Academy of Sciences, which continued work in the Norwegian and Greenland Seas. The principal objective of the voyage was the collection of materials for an analysis of the spatial distribution of the young of fish.

Two voyages of the ship "Ayudag" (Institute of Thermophysics and Electrophysics, Estonian Academy of Sciences) were made in the Baltic Sea. On these voyages studies were made of the synoptic variability of hydrochemical fields and the fine structure of water masses and also the spatial variability of the light field over the Baltic Sea.

Scientists of the Marine Hydrophysical Institute, Ukrainian Academy of Sciences, on their ship "Akademik Vernadskiy," carried out an expedition in the Atlantic Ocean, evaluating the influence of the thermal interaction of the boundary water layers, "defining" regions of oceanic and coastal upwelling of waters. Investigations were also carried out in the Caribbean Sea for clarifying the conditions under which regions of increased bioproductivity are formed.

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UDC 551.463.5

DISTRIBUTION OF CHLOROPHYLL FLUORESCENCE NEAR TEMPERATURE FRONT AREA OF BALTIC SEA

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 1 Dec 82) pp 857-862

KARABASHEV, G. S. and KHANAYEV, S. A., Atlantic Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Kaliningrad

[Abstract] Knowledge of patterns of horizontal distribution of oceanic biological features, so important for understanding the functions of marine organisms for commercial purposes, has been expanded in recent years to include water current patterns and hydrophysical disturbances, but little has been learned about biological occurrences near such disturbances. The present article reports on development of an apparatus for measuring chlorophyll content in ocean sectors based on fluorescence intensity. An impulse xenon lamp with 10 Hz impulse frequency caused fluorescence in a flow-through fluorimeter, and a thermosensor of high linearity and stability recorded sea water temperature. The flow-through method eliminated the need for electric pumps, and the thermosensor was accurate within 0.1°C. The course followed near the Baltic Port of Klaypeda by the scientific research vessel "Shel'f" is outlined. Anisotropy of both fields researched depended largely on the position and orientation of the sailing tacks followed. Results indicated that irregularities in the distribution of chlorophyll fluorescence were tied to concentration factors and the greater diversity in distribution compared to temperature patterns was related to the short life of particles containing chlorophyll. Relatively poor vertical transfer was encountered, even in turbulent seas. Figures 2; references 8: 3 Russian, 5 Western. [255-12131]

UDC 551.46.083:535

TWO-CHANNEL FLOW-THROUGH FLUORIMETER DPF-81 FOR MARINE RESEARCH

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 14 Jan 82, after revision 17 Nov 82) pp 897-899

LILA, A. N. and KHANAYEV, S. A., Atlantic Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Science, Kaliningrad

[Abstract] Various sounding devices have been used to study fields of intensity of fluorescence of phytoplankton pigments and dissolved organic matter, but equipment has been ineffective for studying horizontal variations in such fields. The present article reports on a two-channel fluorimeter with flow-through polyethylene tubes and pumpless operation at any speed above 6 knots. Fluorescence is caused by an impulse lamp adjustable for 10-100 Hz. The device is diagrammed and discussed. The flow-through feature makes special intake procedures unnecessary. The DPF-81 fluorimeter has been tested successfully on the "Shel'f" and "Professor Shtokman" scientific research vessels in the Baltic Sea and Atlantic Ocean. Figure 1; references 9: 5 Russian, 4 Western.
[255-12131]

UDC 581.553:7.021.2

SIMULATION STUDY OF A FOULING COMMUNITY: DYNAMIC PREDICTION OF CHANGES IN SYSTEM FUNCTIONING AND BASIC CHARACTERISTICS OF COMMUNITY FOR VARIOUS VITAL ACTIVITY SIMULATION CONDITIONS

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 4 Aug 82, after revision 6 Jan 83) pp 876-881

GAL'PERIN, M. V., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] Previous studies at the "Azovstal'" plant's hydrotechnical installations developed simulation processes and mathematical and computer data processing of biosystems and their fouling through overgrowth. Abiotic factors and concentrations of nourishing plankton were regarded as stable for any single year, although they fluctuate markedly from year to year. Five series of simulations were studied to generate dynamic predictions of changes in biomass and energy flow for the basic Hydroid community and topically dependent populations Balianus, Tenellia and Vorticella, and finally, crab populations. Patterns of Hydroid population expansion, followed by contraction as Tenellia feeding intensifies, are discussed. Vorticella populations declined as Hydroid numbers increased, then the spawn of Tenellia begin heavy feeding. Next the food spectrum shifts in the direction of Hydroid hydranths, as the process starts over. Intraspecies competition and the limited role of crabs in controlling population only when it is suppressed,

are discussed. With increased Vorticella population, crabs play a more important controlling role as Tenellia devour the Vorticella. Another series was more favorable for Hydroids. Interspecies relations both quantitatively and qualitatively affected the community patterns. Figures 2; references: 5 Russian.
[255-12131]

UDC 551.466

COLLISION OF TWO-DIMENSIONAL SOLITARY ROSSBY WAVES

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 9 Apr 82, after revision 20 Sep 82) pp 725-734

LARICHEV, V. D. and REZNIK, G. M., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] An investigation was made of different variants of collision of two-dimensional solitary Rossby waves; this represents a continuation of work already described by the authors in DOKLADY AKADEMII NAUK SSSR, Vol 264, No 1, pp 229-233, 1982. Each of the following cases are described and illustrated in specific examples: frontal central and acentral collisions and "overtaking" collisions. The analysis revealed that the results of such collisions are essentially dependent on the parameters of the colliding waves. It is shown that in some cases both waves survive, whereas in other cases one of these waves is destroyed; in still other instances the waves merge, forming thereby a bound state. The postulated mechanisms of these interactions are discussed, supported by observationsal data, and compared with the theories and observations of other Soviet and foreign investigators. Figures 13; references 8: 4 Russian, 4 Western.
[27-5303]

UDC 551.46

NUMERICAL MODELING OF MACROSCALE HYDROLOGICAL FIELDS IN OCEAN

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 22 Jun 82) pp 735-742

ZELESNYY, V. B. and MAYEV, V. K., Division of Computation Mathematics, USSR Academy of Sciences, Moscow; West Siberian Scientific Research Institute, USSR State Committee on Hydrometeorology and Environmental Monitoring

[Abstract] A numerical experiment was carried out for studying the behavior of model hydrological fields with a change in the coefficients of turbulent exchange, the influence of change in the zonal component of wind frictional stress on macroscale movement in the ocean and the characteristics of formation of azonal components of heat and mass exchange. It was found that the

most significant restructuring of movement (for the considered scales) occurs with a decrease in the coefficients of horizontal turbulent exchange from $5 \cdot 10^7$ to 10^7 $cm^2 \cdot sec^{-1}$. The principal effect (with respect to the process of heat and mass exchange) is in an increase in the role of the azonal (eddy) component, so that it begins to exert a dominating influence in some regions, such as the southern hemisphere middle latitudes (in the region of convergence of currents), resulting in an increase in the total transport of heat to the north in this region and a fundamental change in the nature of its vertical structure. As a result of the wind effect there is an equatorial upwelling and a related restructuring of processes of transport of heat and mass in the northern part of the basin and also the formation of a convergence of currents in the middle latitudes of the southern hemisphere and positive transport of heat in the southern part of the basin toward the convergence axis. A considerable influence is exerted by a change in the zonal component of wind frictional stress from winter to summer on formation of a negative heat constant anomaly in the northwestern part of the basin and on the nature of vertical movements along the eastern shore. The materials collected in this investigation confirm the possibility of using two-dimensional models for describing the macrocharacteristics of meridional hydrological fields. Figures 3; tables 2; references: 7 Russian.
[27-5303]

UDC 551.466.55

LOCAL UPWELLING AND FRONTOGENESIS IN CASONES BAY (NORTHERN PART OF CARIBBEAN SEA)

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 17 Dec 81; after revision 20 Jan 83) pp 753-756

SKLYAROV, V. Ye. and SUTYRIN, G. G., Institute of Oceanology imeni P. O. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] During the 1st voyage of the "Akademik Mstislav Keldysh" (27 February-13 June 1981) joint work was carried out with Cuban scientists in Casones Bay. This bay is characterized by increased bioproductivity. The article is accompanied by a map of the work region where data were obtained on the thermohaline structure of the upper 150-m layer of the ocean. The data for the different occupied stations are plotted. Analysis of these data reveal the joint effect of two factors: a local upwelling and horizontally inhomogeneous mixing. During the observations there was a stable northwesterly wind. One of the causes of the upwelling may be cyclonic formations forming in the bay under the influence of easterly winds. Another factor possibly responsible for formation of the stationary upwelling of waters may be bottom relief. (In these observations upwelling was observed only in hte upper-150 m layer with a mean depth in the bay of 1,500 m). However, a more probably cause of the local upwelling and frontogenesis is the nonuniformity of the wind field associated with coastal orography. The overall conclusion is that in Casones Bay a spatial nonuniformity of the wind field may be the reason for local upwelling and frontogenesis in the upper layer of the ocean. Figures 3; references 7: 4 Russian, 3 Western.
[27-5303]

UDC 551.463.1

ESTIMATES OF WAVE FLUXES OF MOMENTUM, ENERGY AND ACTION ACCORDING TO IN SITU DATA

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 31 May 82) pp 765-771

ZASLAVSKIY, M. M. and LOBYSHEVA, L. G., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] In situ data obtained in the course of the "Kamchiya-79" experiment on the dependence of momentum, energy and action of wind waves on the degree of their development are used in making evaluations of the fluxes of momentum, energy and action from the atmosphere to the waves expended on wave growth. This takes in the full range of dynamic integral characteristics of interaction between waves and the wind. The computations presented here, with a comparison of the pertinent materials published in the Soviet and foreign literature, makes it possible to clarify the fundamental role of the wave action flux in the processes of development of wind waves and also to make more precise the widely known evaluations made on the basis of measurements from the Joint North Sea Wave Project (JONSWAP) which resulted in the popular, although clearly less informative characteristic for wave-wind interaction--namely the flux of momentum to the waves. References 13: 9 Russian, 4 Western.
[27-5303]

UDC 551.465.4

STRUCTURE OF HYDROLOGICAL FIELDS IN TROPICAL ZONE OF PACIFIC OCEAN ALONG MERIDIAN 180°

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 29 Jun 82) pp 772-776

BUBNOV, V. A. and MOROSHKIN, K. V., Atlantic Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Kaliningrad

[Abstract] The article gives the results of an analysis of hydrological observations along the meridian 180° from 25°N to 16°S carried out during the period 23 October-1 November 1981 on the 27th voyage of the "Dmitriy Mendeleyev." Additional data were used in supplementing these observations. Complete information is given on the temperature and salinity fields. Figures and tables provide data on the dynamic relief of the ocean surface along this meridian, as well as the geostrophic velocities and discharges of zonal currents for latitudes where the geostrophic relations apply. A comparison is made with corresponding observational data collected during the 31st voyage of the "A. I. Voyeykov" in October 1973. Five principal elements of dynamic relief were defined: 1) northern tropical ridge; 2) northern tropical trough; 3) equatorial ridge; 4) equatorial trough; 5) southern tropical ridge.

The compared data for these elements for the two series of observations are in turn compared with corresponding data published by K. Wyrtki (J. PHYS. OCEANOGR., Vol 4, No 4, pp 91-103, 1974). The tabulated data indicate stability of the latitudinal position of the principal elements of dynamic topography, at the same time revealing rather considerable year-to-year changes in the dynamic "heights" of the ridges and troughs. This means that with a relative stability of the latitudinal boundaries the velocity of the zonal surface geostropic currents at 180° experience considerable year-to-year variations. Estimates are given for the discharges of the North Trades Current and the Inter-Trades countercurrent. Figures 3; tables 2; references: 2 Western.
[27-5303]

UDC 551.551.3:551.466.31

NONSTATIONARY MODEL OF DEVELOPMENT OF TURBULENT BOUNDARY LAYER OVER SEA IN PRESENCE OF INITIAL LOGARITHMIC MEAN WIND VELOCITY PROFILE

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 6 Apr 81; after revision 22 Apr 82) pp 777-781

GUMBATOV, A. I. and MAMEDOV, R. M., Space Research Institute; Natural Resources Scientific-Production Association, Kirovabad Branch, Azerbaijan Academy of Sciences

[Abstract] In a series of studies published earlier (A. Yu. Benilov, et al., IZV. AN SSSR: FAO, Vol 12, No 10, pp 1011-1019, 1976; Vol 14, No 11, pp 1174-1187, 1978; OKEANOLOGIYA, Vol 18, No 4, pp 587-592, 1978; Vol 20, No 3, pp 388-394, 1980), on the basis of experimental data on the dynamic properties of the air-water boundary layer, models of interaction between the waves and wind (with few parameters) were proposed in which use was made of the integral laws of conservation of energy and momentum in the wave-wind system. Due to the complexity of the solution, in those studies two alternative models were employed: in one, with the external parameter U_0 = const, it was proposed that all the momentum from the atmosphere is expended on wave formation, whereas in the other model the external parameter used was the current velocity $U*_0$ of a steady turbulent current over a smooth underlying surface unperturbed by waves. The choice of the external parameter $U*_0$ = const also makes possible additional allowance for the effects of viscous friction in the near-water layer of the atmosphere. This article is based on these earlier studies, but in contrast to these the quasistationary approximation of the balance of turbulent energy is replaced by a full nonstationary equation more precisely describing the evolution of the characteristics of turbulence in the atmospheric boundary layer. Numerical computations are made using this refined model. Comparison with the earlier results indicates that appreciable differences in the dynamic characteristics are obtained in the initial stages of development of surface wind waves. As the surface wind waves develop these differences disappear. Figures 2; references 7: Russian.
[27-5303]

UDC 551.463.8

ENERGY STRUCTURE OF TURBIDITY FLOW

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 3 Sep 82) pp 846-850

PYRKIN, Yu. G., SAMOLYUBOV, B. I., GALKIN, S. V. and SILAYEV, M. A., Moscow State University imeni M. V. Lomonosov

[Abstract] In situ investigations of a bottom density current with mechanical stratification carried out in different years in different stages of flow development have revealed a considerable inhomogeneity of the vertical distributions of the concentration of particles suspended in the water. Investigation of this phenomenon for a complex case of stratification caused by the presence of suspended particles measuring 2-70 μm in the flow required the creation of special apparatus and the development of methods for carrying out discrete and continuous in situ measurements of the principal hydrodynamic characteristics of the current. In addition to complex profile registry of these parameters, the method developed by the authors made it possible to carry out measurements of the certical distributions of water temperature and precise analysis of the granulometric composition of the suspended particles. Samples were taken at intervals of 0.5-1 m. After determining the concentration of suspended matter its granulometric composition was investigated using an automatic image analyzer. The accuracy in determining particle size was 0.5 um in the size range 2-70 μm, broken down into 12-16 classes (fractions). At least 6 10^3 particles were analyzed in each sample. A special program was used in automatic computation and plotting of the percentage quantitative and volumetric content of particles. The measurements revealed that the energy structure of a natural turbidity current is a system of centers of generation of turbulence distributed in the thickness of the flow. Ensuring the maintenance of particles in suspension in bottom currents with a thickness of tens of meters, this structure is evidently the main form of existence of large-scale turbidity flows. Figures 3; references 14: 12 Russian, 2 Western. [27-5303]

UDC 551.465.15

METHOD FOR CLASSIFYING SECTORS OF RECORDS OF MICROSCALE FLUCTUATIONS OF HYDROPHYSICAL FIELDS

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 (manuscript received 24 May 82) pp 882-886

BELYAYEV, V. S. (deceased) and BUNIMOVICH, L. A., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] The authors propose a new approach to the breakdown of sectors of a fluctuating signal of small-scale fluctuations of hydrophysical fields into two classes, making it possible to use an arbitrary number of parameters.

This is done on the basis of the methods of the statistical theoty of classification with a priori information on one of the classes taken into account. The classification procedure is as follows. First a signal record is formed which consists entirely of sectors of a record of one class (teaching sample). This is used in formulating a decision rule (classifier) which is then applied to real records. All the records are classified using one and the same teaching sample. The choice of the teaching sample is based on the use of several main components with minimum eigenvalues. The procedures are illustrated in the example of breakdown of the signal of small-scale current velocity fluctuations in the ocean into "laminar" and "Turbulent" sectors of the record. The full algorithm for such procedures is presented. Figures 1; references 7: 6 Russian, 1 Western.
[27-5303]

UDC 551.462:551.46.07(261)

GEOLOGICAL-GEOPHYSICAL EXPEDITION TO CENTRAL AND SOUTH ATLANTIC

Moscow OKEANOLOGIYA in Russian Vol 23, No 5, Sep-Oct 83 pp 900-903

YEMEL'YANOV, Ye. M., DMITRIYEV, L. V., YEL'NIKOV, I. N., TRIMONAS, E. S. and KHARIN, G. S.

[Abstract] A geological-geophysical expedition to the central and south Atlantic took place during the period 14 February-30 May 1982 (a full-page map of the ship's track accompanies the text). The objective of the expedition was study of the rift valley of the South Atlantic Ridge between 20 and 30°S (polygon I) and study of the geological structure of the Sierra Leone Rise (polygon II). Geological-geophysical investigations were made along the track. A total of 23 specialists participated (Atlantic and Southern Divisions, Institute of Oceanology, Geochemical Institute, Geological Institute). The expedition, aboard the "Professor Shtokman," was headed by Ye. M. Yemel'yanov. The investigations included echo-sounding measurements, continuous seismic profiling, multichannel seismic profiling, dredging and petrographic study of igneous and sedimentary rocks, study of Late Quaternary sediments, collection of eolian and water suspensions while the ship was proceeding on course and study of the concentration of dissolved organic matter. Various aspects of this work are summarized. In particular, near the South Atlantic Ridge it was possible to refine the position of the rift valleys and transformed faults and detect a number of new faults not shown on existing bathometric charts. For the first time an unusually thorough study was made of this part of the ridge, which it was found can be divided into two sectors: northern and southern, the boundary between them evidently running between 27 and 28°S. These two sectors are probably characterized by different geodynamic regimes. In polygon II, the Sierra Leone Rise, several types of deep faults were discovered. The various data suggest that this rise was formed in the Cretaceous in the initial stages of expansion of the Atlantic. Inset maps of the two polygons show the stations occupied and types of measurements made. Figures 1.
[27-5303]

UDC 551.465.752

SURFACE PRESSURE DISTRIBUTION AT WAVE-COVERED SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 10, Oct 83 (manuscript received 24 Jun 82) pp 1098-1101

MAKIN, V. K. and PANCHENKO, Ye. G., Institute of Oceanology, USSR Academy of Sciences

[Abstract] A numerical model of the boundary layer over monochromatic waves was developed by V. K. Makin in OKEANOLOGIYA, Vol 19, No 2, pp 205-212, 1979. Here the authors introduce changes into this model making it possible to refine the pressure computations. In the model use is made of an explicit-implicit difference scheme usual for Navier-Stokes equations. The right-hand sides of the equations for the velocity components (denoted $F_u{}^t$, $F_w{}^t$) are computed using an explicit scheme and pressure is determined from the elliptical equation

$$D(\rho^{-1}G^x(p^{t+1}),\ \rho^{-1}G^{\xi}(p^{t+1})) = D(F_u{}^t + U^t(\Delta t)^{-1},\ F_w{}^t + W^t(\Delta t)^{-1}. \quad (1)$$

where x is the horizontal, $\xi = Z - \eta$ is the vertical coordinate, reckoned from the surface of a wave with the profile η ; G^x, G^{ξ} are difference operators for differentiation of the scalar field; D is a divergence difference operator; p^{t+1} is the pressure in the t+1st interval; U^t, W^t are the horizontal and vertical velocity components in the t interval; Δt is the time interval; ρ is air density. In the article cited above equation (1) was solved by the upper relaxation method. With an apt choice of the interval Δt and the relaxation parameter R the iteration method converged quite rapidly for a relatively small stipulated accuracy but the choice of these parameters was difficult. In the new model equation (1) is solved by the matrix trial run method. In this method with the same number of arithmetical operations it ensures a higher accuracy in computing the pressure field. The number of arithmetical operations is not dependent on the R, parameters and is determined only by the number of points of intersection in the spatial finite-difference grid. For solution of (1) by the matrix trial run method the equation is written in vector form. Numerous tests indicated the reliability of the method. In most cases the new solution method gives a gain in the time required for solution of the elliptical equation (1) and ensures a greater accuracy in the computations. An example is given. Figures 2; 10 references: 8 Russian, 2 Western.
[28-5303]

UDC 551.463.5:535.31

DETERMINING IMAGE QUALITY OF TEST OBJECTS OBSERVED THROUGH WATER SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 10, Oct 83 (manuscript received 15 Mar 82) pp 1095-1098

VEBER, V. L., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] The images of test objects observable through a wave-covered water surface will be distorted. The appearance of distortions is caused

for the most part by the presence of a scattering medium and an uneven water-air interface which refracts the light rays in different directions. In has been demonstrated previously that the principal characteristics determining image quality are the spatial frequency contrast characteristic of the water layer and backscattering noise. These characteristics can be used in evaluating image contrast and the limiting range of visibility under water. A theory of image transfer through the wave-covered water surface has been developed. A number of studies have given an analysis of image characteristics averaged for great space-time intervals, but there has been no evaluation of the quality of unaveraged (instantaneous) images. The author has therefore developed a system of generalized image quality tests obtained with extremely small averaging intervals. A series of four expressions was written for describing different types of distortions: 1) describing multiplicative distortions, 2) linear distortions, 3) geometrical distortions, 4) additive distortions. On this basis it was possible to formulate a quality test--the normalized measure of image deviation $B(r)$ from an ideal image $B_0(r)$--Q_0, for which an appropriate expression is written. An alternative test, Q_1, is also derived. A combination of Q_0 and Q_1 more fully characterizes the measure of closeness (or deviation) of images $B(r)$ and $B_0(r)$ than the single test Q_0. The Q_0 and Q_1 tests are simple and physically graphic. Computations of Q_0 and Q_1 requires a knowledge of the depth of the test object, the dispersions of slopes and the curvature of the waves, the medium scattering function, mean components and correlation functions of the object and illumination, mean value and dispersion of the background. There is reason to believe that the evaluation of distortions following from the Q_1 test will be close to man's subjective evaluation. Figures 1; references 12: 11 Russian, 1 Western. [28-5303]

UDC 551.466.31

TRANSVERSE INSTABILITY OF WAVES AT SURFACE OF FLUID WITH FINITE DEPTH

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 19, No 10, Oct 83 (manuscript received 29 Apr 82, after revision 23 Sep 82)
pp 1068-1074

LAVROVA, O. Yu., Institute of Oceanology, USSR Academy of Sciences

[Abstract] The stability of the wave field at the surface of a fluid of arbitrary depth was investigated. The spectrum of waves is assumed to be narrow with respect to transverse wave numbers and broad with respect to longitudinal wave numbers k. An equation for Ψ_k is derived from the known Hamilton equations for the dynamics of the field of slightly nonlinear waves (Ψ_k is the Fourier amplitude of the wave field), generalizing the known nonlinear Schrödinger equation for the case of a broad k spectrum. A linearlized equation is used in making an analysis of the transverse stability of waves. It is demonstrated that at the surface of a deep fluid the arbitrary wave spectrum is stable with respect to long-wave transverse modulation. At the surface of shallow water there is an instability with certain space and

time scales determined by the energy and form of the wave spectrum. The materials presented in the article reveal transverse stability of an arbitrary quasi-one-dimensional wave spectrum in deep water relative to long-wave modulation. The transverse inhomogeneity of wind waves observed in nature is therefore caused by factors not taken into account in this formulation of the problem, especially inhomogeneity of the wind field and nonconservative mechanisms of wave interaction. There is a transverse instability of waves in shallow water with a characteristic space scale $2\pi/p^*$ which is determined by the intensity of the waves and the form of the spectrum. This must be taken into account in an analysis of the results of measurements of the characteristics of wind waves in shallow water. References 10: 8 Russian, 2 Western.
[28-5303]

UDC 551.511.6

STATISTICAL PROPERTIES OF ADMIXTURE MIXING BY TWO-DIMENSIONAL TURBULENCE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 19, No 9, Sep 83 (manuscript received 24 Nov 82) pp 902-912

MIRABEL', A. P. and MONIN, A. S., Institute of Oceanology, USSR Academy of Sciences

[Abstract] The principal property of two-dimensional turbulence, distinguishing it from three-dimensional, is the existence of two inertial intervals of scales, in one of which there is a spectral transfer of energy with the rate $\mathcal{E}$ to larger scales (small wave numbers k), and in the other--spectral transfer to enstrophy with the rate $\mathcal{E}_\omega$ in the direction of greater k. If there is a localized "feeding" of a current of energy and enstrophy in the neighborhood of the wave number k_0, to the left of k_0 an energy spectrum $E(k) \sim k^{-5/3}$ is established in the energy transfer sector, but to the right, in the enstrophy transfer sector, the energy spectrum will decrease in conformity to the law $E(k) \sim k^{-3}$. This article examines a situation in which a passive admixture with the concentration θ is introduced into a two-dimensional turbulent flow with a high Reynolds number. The authors give computations of the spectral and structural functions, coefficient and scale of mixing of a passive admixture in the inertial interval of enstrophy transfer in the spectrum of two-dimensional turbulence with logarithmic corrections for the nonlocality of interaction between modes. Theoretical predictions for the mixing scale are compared with experimental data on the dispersal of constant-level balloons in the atmosphere. Figures 2; references 18: 13 Russian, 5 Western.
[25-5303]

UDC 551.465.7

TEMPERATURE DISTRIBUTION NEAR OCEAN SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 11 Aug 80, after revision 10 May 82) pp 1000-1002

KAMENETSKIY, Ye. S. and KAZAROV, A. A., Severo-Osetinskiy State University

[Abstract] A method is proposed for computing the temperature profile and drop in the surface film as a function of wind velocity and water temperature in the case of forced convection. Here an improved Prandtl method is used in deriving an expression for the heat flow. This expression is transformed for the stationary case when the heat flow and frictional stress near the phase interface can be regarded as constants. The mean velocity profile in the immediate neighborhood of the phase interface is determined. A transformed differential equation is derived for the temperature distribution. It is assumed that there is a constancy of the Prandtl turbulence number in the entire film. With this assumption the temperature profile in the film is obtained in explicit form. It is shown that it is possible to evaluate the thickness of the film and find the value of the coefficient in the Saunders formula, and also compare the computed and experimental temperature profiles. An example of numerical computations is given. References 5: 3 Russian, 2 Western.
[25-5303]

UDC 551.465.11:551.465.48

NUMERICAL PREDICTION OF CURRENTS IN OPEN OCEAN

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 25 May 82, after revision 12 Oct 82) pp 965-970

SEIDOV, D. G. and YUSHINA, I. G., Institute of Oceanology, USSR Academy of Sciences

[Abstract] A method for numerical prediction of currents in the open ocean is proposed which is based on a simple hydrodynamic prediction for the entire region with the assimilation of information but only at the boundary of the region or along individual parts of this boundary. Such computations are oriented on a special method for carrying out expeditionary observations. In such a regime a ship makes a hydrological survey in a polygon and then makes runs along the polygon perimeter. In another variant two vessels after a survey make runs, one along the eastern boundary and another along the western boundary of the polygon. Other versions are conceivable. Such possibilities were investigated in a numerical forecast of synoptic currents with simulation of the mentioned measurements, the data employed being taken

from POLYMODE observations. Data for two surveys were taken: initial and control. All the surveys were made in a square with its center at the point 29°N and 70°W, the polygon measuring approximately 280 x 280 km where 25 stations were occupied with soundings from the surface to the bottom. These data were used in retrieving the density field at the horizons 0, 200, 500, 1,000 and 1,500 m. The data were interpolated in a grid of 17 x 17 points at all five horizons and were smoothed with a cosine filter. The specific, detailed example presented here appears to indicate a good result, making it possible to simulate and precompute the general tendencies in evolution of currents in the open ocean, but only further experiments with the model and special observations will reveal whether such an approach is practical for predicting currents in the open ocean. Figures 3; references 6: 5 Russian, 1 Western.
[25-5303]

UDC 551.465.75

NUMERICAL MODELING OF STRATIFIED OCEAN RESPONSE TO MOVING TYPHOON

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 20 Aug 82, after revision 7 Jan 83) pp 971-980

DIKINOV, Kh. Zh. and SEDNEV, I. L., Kabardino-Balkarskiy University

[Abstract] A result of the effect of a tropical cyclone (TC) on the ocean is the formation of a thermodynamic track with a width of several hundred meters. In the vertical plane perpendicular to TC movement a circulation is formed which leads to the redistribution of water masses in the entire region affected by the hurricane. The ocean surface temperature decreases by several degrees and the vertical thermal structure of its waters is characterized by an alternation of layers with increased and decreased temperature relative to its values in an unperturbed state. Changes in the temperature field are traced to depths of some hundreds of meters and their lifetime is several weeks. In this article, on the basis of earlier studies (Ginis, I. D., et al., OKEANOLOGIYA, Vol 21, No 5, pp 794-801, 1981; DOKL. AN SSSR, Vol 260, No 4, pp 1005-1008, 1981), the authors describe a nonlinear three-dimensional space model which is used in studying the changes transpiring in the thermodynamic structure of a stratified ocean exposed to a moving typhoon. It is assumed that the ocean consists of an UQL of the thickness h, a thermocline layer with the thickness H and an infinite abyssal layer. The basis of the model is the continuity equation, equations for conservation of heat and momentum, integrated vertically within the limits of the discriminated layers, in writing which use is made of the following assumptions: the quasistatic approxiaation is adopted, the Coriolis parameter is considered constant; the current velocity and water temperature in the UQL are constant in depth; the abyssal layers in which the water temperature is constant are considered fixed as a result of their infinity; in the thermocline the current velocity does not change within the entire layer, whereas the water temperature continuously

decreases with depth; at the interface between the UQL and thermocline layer there is a discontunity of current velocity and the temperature jump. This model was used in making numerical computations, making it possible to draw these conclusions: The reaction of the ocean in the zone of a significant effect of a moving typhoon has a clearly expressed asymmetry. The greatest cooling of the ocean surface and the region of maximum current velocities in the UQL is observed to the right of the trajectory of hurricane movement. The effect of a moving typhoon on a stratified ocean causes in the latter an upwelling leading to a domed rising of isotherms in the track under the trajectory of hurricane movement. The forming domed rising of isotherms favors formation of a current constituting a stable cyclonic circulation in the thermocline. Figures 5; references 19: 13 Russian, 6 Western.
[25-5303]

UDC 551.465.72

HEAT EXCHANGE IN THIN WATER-AIR BOUNDARY LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 17 Mar 82, after revision 22 Oct 82) pp 981-986

ANISIMOVA, Ye. P., BELOV, Yu. N., NIKITINA, Ye. A. and SPERANSKAYA, A. A., Moscow State University

[Abstract] The authors give the results of investigations of the structure of the warm air-water boundary in the absence of heat advection under conditions when the heat flow is directed from the water surface to the air. This represents a continuation of work already published (Ye. P. Anisimova, et al., IZV. AN SSSR: FAO, Vol 13, No 3, pp 320-324, 1977; VESTN. MGU: FIZIKA, ASTRONOMIYA, Vol 13, No 4, pp 17-25, 1977). Emphasis here is on investigation of the temperature field in the centimeter air layer and in the 4-mm layer directly adjacent to the water-air interface. In the near-water air layer with a thickness of 1 mm and in the surface water layer of the same thickness the discreteness of temperature measurements was 0.2 mm. In the layers more distant from the interface the interval between measurement horizons was greater. The investigations were made with water surface temperatures from 32 to 41°C and with a room temperature of 20°. The work was done in winter when room relative humidity was only 4%. Water and air temperature measurements were made with a copper-constant thermocouple with a response to 0.1°C/mm. Registry was with a loop oscillograph for 100 sec at each measurement horizon. These records were used in computing the mean temperatures and dispersions of temperature fluctuations at each horizon. The method essentially involves determination of water surface temperature by extrapolation of the linear part of the mean temperature profile in the surface water layer to the water-air interface. The computations presented here indicate the validity of the proposed method. The method can be used when radiation measurements are inapplicable, such as when there is increased humidity in the near-water air layer. Figures 3; references 8: Russian.
[25-5303]

SOVIET INVESTIGATIONS OF EARTH'S GRAVITY FIELD

Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 83 pp 23-27

[Article by M. Ye. Kheyfets, doctor of technical sciences]

[Text]

The General Gravimetric Survey in the USSR began more than 50 years ago. Its results exerted an important influence on study of the earth's figure and internal structure, exploration for minerals and space exploration.

Earth's Figure and Gravity Field

Already in the 17th century it was established that in general the acceleration of gravity increases from the equator to the earth's poles. I. Newton attributed this to the fact that gravity is the resultant of the forces of attraction of all material particles of the earth and the centrifugal force of its rotation about its axis. The latter also transformed the earth from a sphere into a flattened ellipsoid of revolution (spheroid). Accordingly, at the equator, where the centrifugal force is maximum and the surface points are most distant from the center of the earth, gravity is minimum.

Since the elevation of mountain ranges and ocean depth even in the deepest depressions are small in comparison with the earth's radius, the earth's figure is close to the form of the ocean surface, that is, should be, as it is customary to say in mechanics, a gravity level surface. Accordingly, not only gravity, but also the earth's figure, are dependent on the distribution of mass within it, centrifugal force and flattening of the spheroid approximately representing the earth.

In the 18th century the French mathematician Clairaut derived simple mathematical expressions relating gravity to the earth's size and figure, centrifugal force and the geographical latitude of a particular point. This expression contains two parameters -- gravity at the equator and the coefficient of its change with geographical latitude. By measuring gravity at two points separated by the maximum distance in latitude it is possible to determine the mentioned parameters and then, using the argument of latitude, compute gravity for any point on the earth. These are called normal values. The deviations from the actually measured values -- gravity anomalies -- are extremely

small: on the average they are several units of 10^{-5} of gravity and only in rare cases do they attain units of 10^{-4}.

The level surface, representing the earth's figure and in the oceans coinciding with their unperturbed surface, in the last century was given the name "geoid" (ZEMLYA I VSELENNAYA, No 4, p 56, 1979 -- Editor). The difficult investigation of the geoid was considerably facilitated with the appearance of the concept of potential in mechanics. G. G. Stokes, in the middle of the last century, demonstrated an important theorem: if the figure of the level surface of a body completely enveloping its entire mass and the angular velocity of rotation are stipulated, it is possible to compute the potential values for any point both at the surface and in the entire external space, regardless of the distribution of mass within it. Theoretically he also solved the inverse problem -- determination of the level surface on the basis of the gravity values measured on it. Thus, on the basis of the Stokes theorem it was possible to refine the Clairaut formula without having recourse to any hypothesis concerning the distribution of mass within the earth.

Gravimetry Among the Earth Sciences

The Stokes formula enables geodesists to determine the height of the geoid above some selected normal spheroid. But it is still more important to know the angles between the normals to the geoid and the mentioned spheroid and precisely these angles, called plumb line deflections, constitute the difference between the astronomical coordinates, measured directly, and the geodetic coordinates, computed relative to the spheroid. In the 1920's F. A. Vening-Meinesz, using the Stokes formula as a point of departure, proposed a method for determining plumb line deflection exclusively on the basis of gravity measurements, which in principle makes it possible, with any degree of detail, to investigate the figure of the geoid. The method was immediately tested in the USSR by Professor I. A. Kazanskiy.

However, the practical application of the Stokes and Vening-Meinesz formulas meets with considerable difficulties. This is attributable to the fact that first of all it is necessary to have information on gravity anomalies over the entire earth, whereas at the beginning of the 1930's the gravimetric study of the USSR, like other countries, was weak. In addition to this, according to the Stokes theory, outside the geoid there should be no attracting masses, but on the continents this condition is not observed and therefore the rigorous construction of the geoid is impossible. Finally, there had to be a substantial increase in the accuracy of measurements and their results had to be expressed in a unified system.

Similar requirements arose among geophysicists and geologists. Their attention was focused on major anomalies or gradients of anomalies in regions rich in minerals, in seismically active and some other regions. They were also interested in the correlation between gravity and magnetic anomalies, between data from gravimetric and seismic investigations. As a result, the problem of gravitational exploration of minerals arose. It could be used for the first time in 1921 in seeking iron ore deposits in the region of the Kursk magnetic anomaly and then came into use in seeking petroleum, gas and deposits of other minerals. Outstanding Soviet scientists -- A. D. Arkhangel'skiy,

I. M. Gubkin, B. V. Numerov, V. V. Fedynskiy and others -- have been concerned with the problems involved in gravimetric prospecting. In particular, their efforts were directed to overcoming one of the fundamental difficulties -- ambiguity in solution of the inverse problem in gravimetric prospecting. The essence of the inverse problem is as follows: for the geological interpretation of gravity anomalies the distribution of masses within the earth is computed on the basis of the measured parameters of the gravity field. But this problem, in contrast to the direct problem, when on the basis of the distribution of masses their gravity field is found, does not have an unambiguous solution. Nevertheless, Soviet scientists have been able to find a number of special cases when the inverse problem is nevertheless solved virtually unambiguously or when it can be reduced to solution of the direct problem, selecting an appropriate model of the distribution of masses within the earth. But the best method for excluding the ambiguity of solution was a method in which gravimetric prospecting is combined with other types of geophysical and geological prospecting.

Gravimetric Survey in USSR

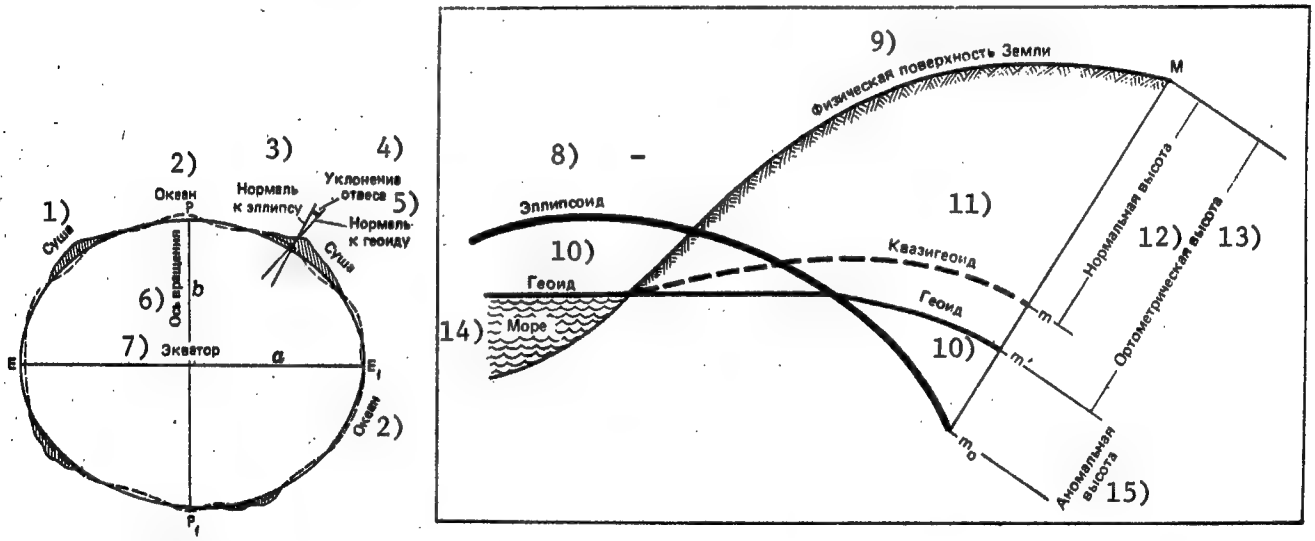
In pre-Revolutionary Russia very definite gravimetric traditions developed: already two centuries ago M. V. Lomonosov expressed a number of original gravimetric ideas. Major (for that time) expeditionary work (F. P. Litke, I. F. Parrot, and others) was executed in the 1870's. A great contribution to gravimetry was made by the investigations of B. Ya. Shveytser, P. K. Shternberg and F. A. Sludskiy, who opened new pages in study of the figure and internal structure of the earth. A major role in solving instrumental-methodological problems was played by D. I. Mendeleyev. The leading Soviet scientists A. A. Mikhaylov and I. A. Kazanskiy also began their active scientific activity in the field of gravimetry already in the pre-Revolutionary period.

In the 1920's and 1930's many organizations in the USSR began to be concerned with the gravimetric survey. But in many cases they duplicated one another, dissipating the technical resources which were so limited in those days. The situation with gravimetry developing in the USSR by the 1930's became the object of discussion at a geological-geodetic conference in 1932. On the recommendations of this conference the USSR Council on Work and Defense on 20 September 1932 issued a Decree on Implementation of the USSR General Main Gravimetric (Pendulum) Survey. The task of the survey was entrusted to the Main Geodetic Administration of the People's Commissariat of Heavy Industry (now the Main Administration of Geodesy and Cartography of the USSR Council of Ministers), and the latter, in collaboration with all interested departments and institutions, carried out rigorously planned work on a practical survey, its many-sided support and implementation of scientific investigations.

In order to solve geodetic and other problems it is necessary to project the points of the complex physical surface of the earth onto the surface of a simple geometrical body (spheroid); for this it is necessary to know the heights of these points above the spheroid (geodetic heights). In traditional geodesy it was assumed that for this purpose it is sufficient to determine the height above the geoid from geometrical leveling and add to this the heights of the geoid above the spheroid determined from astronomical leveling.

However, as already mentioned, a rigorous determination of the geoid on the continents is impossible, as is a rigorous reduction of geodetic measurements made on the earth to its surface.

A solution of this problem was found in the 1950's by M. S. Molodenskiy. He proposed dispensing with the representation of the earth's figure as a level surface and that the geoid be replaced by another auxiliary surface -- the quasigeoid. The latter is determined unambiguously on the basis of astrogeodetic and gravimetric measurements at the earth's surface. A noteworthy feature of the quasigeoid is that in the oceans it fully coincides with the geoid; in lowland regions on the continents it only deviates by centimeters from it and only in the mountains can the deviation from the geoid be 1-2 m. Thus, using the quasigeoid it is not necessary for the most part to depart in principle from traditional, well-developed methods for solving geodetic problems. It is only necessary to transform to a new system of heights: from orthometric heights (heights above the geoid, not determined unambiguously) to normal heights. These normal heights are obtained from the increments of gravity potential along level lines on the basis of leveling data and gravity measurements. The geodetic height is found as the sum of the normal height and the "height anomaly," or the height of the quasigeoid above the reference spheroid (ZEMLYA I VSELENNAYA, No 4, p 56, 1979 -- Editor).



Left: Influence of anomalous mass on direction of plumb line deflection. Right: System of heights used in geodesy. These heights are deviations of the physical surface of the earth from the quasigeoid, geoid and ellipsoid (or spheroid).

KEY:

1. Land
2. Ocean
3. Normal to ellipse
4. Plumb line deflection
5. Normal to geoid
6. Axis of rotation
7. Equator
8. Ellipsoid
9. Physical surface of earth
10. Geoid
11. Quasigeoid
12. Normal height
13. Orthometric height
14. Sea
15. Anomalous height

The success of the M. S. Molodenskiy theory, crowning important investigations of a number of Soviet scientists -- F. N. Krasovskiy, N. D. Moiseyev and others, in many respects was due to implementation of the USSR General Gravimetric Survey; its results enabled M. S. Molodenskiy to confirm his conclusions experimentally. The effectiveness of this theory can be judged, for example, by the fact that flattening of the Krasovskiy ellipsoid (such an ellipsoid was adopted for the processing of geodetic measurements in the USSR), determined by F. N. Krasovskiy and A. A. Izotov more than 40 years ago, virtually coincides with the flattening obtained using modern data (ZEMLYA I VSELENNAYA, No 3, p 44, 1969 -- Editor). But the new gravimetric materials made it possible with great accuracy and detail to study the figure of the quasigeoid in the USSR, to determine how the Krasovskiy ellipsoid is oriented in the earth's body and to investigate the earth's outer gravity field.

Substantial successes were also attained in the geological-geophysical and geological prospecting aspects of use of gravimetry. It could be demonstrated that the local gravity anomalies detected on the basis of the results of a gravimetric survey are dependent primarily on density inhomogeneities of the earth's upper layers, the nonhorizontality of interfaces of masses of different density, on the depth and dimensions of the investigated objects. Regional anomalies make it possible to study the deep structure of the earth's crust, to determine the relief of its lower boundary, to discriminate geosynclinal and platform regions. The extension of the survey to the earth's entire territory will make it possible to determine a number of planetary parameters of the earth's figure and internal structure.

Methods for Measuring Gravity Field

Now we will examine the principles and methods for measuring the gravity field. Different kinds of instrumentation are used for determining gravity. The highest measurement accuracy is provided by ballistic gravimeters. These make it possible to measure the absolute acceleration of free falling of a test body. In pendulum instruments the sensors are oscillating pendulums. By measuring their length and period of oscillations it is possible to compute absolute gravity. But since determination of the pendulum length involves great difficulties, recently pendulums have been used only for relative gravity measurements. In this case only the difference or the ratio of the gravity values at two points are determined and the precise length of the pendulum may not be known, if, to be sure, it remains knowingly identical at both points.

Static gravimeters came into wide use in the 1930's; these are special high-response spring balances. With these instruments the measure of change in the weight of a test body in them is the deformation of the spring to which it is suspended. Numerous gravimeters of this type have become the principal instruments for gravity investigations. String gravimeters are also in use: the change in gravity from point to point is judged from the frequency of the characteristic oscillations of the string on which the test body is suspended. These gravimeters are convenient for operation on aircraft, helicopters and ships. In certain cases use is made of variometers and gradient meters which make it possible to determine the gravity gradient, that is, the measure of nonuniformity of the gravity field in a stipulated direction.

The accuracy in modern surface determinations of gravity is close to 10^{-8} of its absolute value. It decreases by two orders of magnitude (to 10^{-6} of its absolute value) in the case of sea and aircraft measurements. This is attributable to the fact that it is difficult to take into account any kind of perturbation of acceleration appearing during measurements in the course of movement.

Soviet scientists and designers have made a major contribution to the creation of gravimetric instruments. Already in the 1930's V. B. Numerov proposed that gravity measurements be made using a Golitsyn vertical seismograph. This idea, developed by Soviet scientists, later came into use throughout the world. Better gravimeters (including Soviet gravimeters developed by Professor K. Ye. Veselov) were constructed on this principle. K. Ye. Veselov also proposed the use of strongly damped gravimeters for sea measurements of gravity.

In the 1940's M. S. Molodenskiy proposed the design of a new gravimeter model with an annular metal spring. He had the idea of the possibility of constructing a gravimeter not requiring calibration (experimental determination of coefficients for transforming gravimeter readings into gravity values). The latter was realized under the direction of Yu. D. Bulanzhe. In the case of gravimeters requiring calibration Yu. D. Bulanzhe constructed a special apparatus simulating changes in the acceleration of gravity by instrument tilt. A pendulum method for measuring gravity was developed in the USSR under the direction of M. Ye. Kheyfets and instrumentation was created for surface and sea determinations at a modern level of accuracy. G. P. Arnautov, V. P. Koronkevich and other specialists created the GABL highly accurate ballistic gravimeter. A. M. Lozinskaya developed a string gravimeter used together with a special navigation complex for measurements from flight vehicles. Gravimeters were also created for measurements in shafts and exploratory boreholes, as well as bottom gravimeters and gradient meters.

Many efforts have been invested by Soviet gravimetrists in creating a method and technology for use of the instrumentation, for ensuring unity of the measurement system at the scale of the entire country, and also for uniformity of methods for processing and evaluating measurement accuracy. Suffice it to mention that during the last 50 years the accuracy of gravity measurements has increased by a factor of more than 100. In the USSR all these measurements are tied in to a system of control points of different classes of accuracy, all the stations are rigorously interconnected and are also connected to foreign highly accurate control points.

Prospects for Gravimetry

With the appearance of artificial earth satellites gravimetry was afforded new possibilities. As is well known, satellites are in a state of continuous free falling. This makes possible their use for determining the parameters of the gravity field much like the use of a falling test body in a ballistic gravimeter. A combination of satellite measurements with land and ocean measurements will enrich our knowledge with new and valuable information concerning the gravity field, will upgrade the accuracy in computing the orbits of space vehicles and will ensure the possibility of autonomous determination of coordinates of

points on the earth's surface. By carrying out highly precise radioaltimetric measurements of satellite altitudes above the ocean level it is possible without gravity measurements to determine the figure of the geoid geometrically, and from it determine the earth's gravity field.

A rapid increase in the accuracy and volume of work is widening the effectiveness of gravimetric investigations. It is difficult, for example, to overevaluate the successes of gravimetric prospecting. A correlation between the microstructure of the gravity field and deposits of hydrocarbons has already been discovered; the principles for predicting deposits are being formulated; the list of minerals which can be detected by means of gravimetric prospecting is increasing. The detailed microstructure of the gravity field is also necessary for determining local plumb line deflections in the geodetic support of engineering construction work, such as for accelerators of elementary particles and hydroelectric power stations.

Modern metrology imposes high requirements on gravimetry: the creation of standards for force, pressure and current strength requires a constant increase in the accuracy of gravity measurements. Radioaltimetric measurements from satellites in combination with precise gravity measurements from ships are affording prospects for a detailed study of deviations of the ocean surface from the geoid, and this is important for oceanology. Unlimited possibilities are opening up before gravimetry in the study of space and the gravity field of other planets. The importance of gravimetry for navigation is increasing: now the importance of gravimetry is being expressed in other ways. Inertial systems are in increasing use for the autonomous determination of coordinates, and it requires a detailed knowledge of the gravity field.

However, the most important modern application of gravimetry is evidently its application to solution of problems in the field of geodynamics, studying temporal changes of the earth's surface, its internal structure and and geophysical fields, as well as tectonic processes and movement of lithospheric plates. This field also includes support for the prediction of seismic and volcanic phenomena, an increase in the accuracy of solutions of geodetic problems and the effectiveness of gravimetric prospecting, investigation of the nonuniformity of the earth's rotation and migration of its poles, changes in ocean level, stability of the gravitational constant and observation of changes in gravity caused by man's activity.

The difficulties of geodynamic investigations can be judged from the fact that according to computations gravity variations attain only 10^{-8}. But in some local processes such as earthquakes and volcanic eruptions or technogenic effects both in the USSR and abroad there is reliable registry of greater variations as well -- on the order of 10^{-7}. Variations of the same magnitude have also been measured in underground gas reservoirs where they are becoming an important object of observations for monitoring the discharge of gas.

Geodynamic theoretical and experimental investigations are already being carried out on a practical basis. Their leading role in gravimetry of the immediate and

more remote future is without question and this will require a further increase in accuracy and broadening of gravimetric survey scales.

5303
CSO: 1865/43

UDC 550.83:551.1

DETERMINING DENSITY OF UPPER MANTLE ROCKS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 3, Nov 83 (manuscript received 26 Apr 83) pp 695-698

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[Abstract] A method is proposed for determining the density of upper mantle rocks. The method is based on the results of a total quantitative interpretation of gravity anomalies which was carried out on the assumption of a block nature of the anomalous objects. The density determination method is based on the following main assumptions: 1) the vertical gradient of change in the density of upper mantle rocks in the upper mantle $\partial\sigma/\partial H$ = const, σ is density, g/cm^3, H is depth, km); 2) $\partial\sigma/\partial H$ in the two adjacent blocks coincides in value; 3) the blocks as independent geological bodies developed at a definite stage in geological history as a result of vertical movements with the amplitude ΔH along a fault which broke a once-homogeneous block into parts. Appearance of a density jump $\Delta\sigma$ in a horizontal direction in the fault is associated with vertical movements of such blocks. With an equality of the vertical gradients $\partial\sigma/\partial H$ in both blocks the $\Delta\sigma$ value will be constant in the fault separating them and is determined by the expression

$$\frac{\partial\sigma}{\partial H} H = \Delta\sigma.$$

The $\Delta\sigma$ parameter is known from interpretation. The amplitude of the vertical displacement of the blocks ΔH can be evaluated on the basis of an analysis of the history of geological development of the region; amplitude can also be evaluated from the displacement of deep reference boundaries on the two sides of the fault. In some regions the Moho can be used as the reference horizon. It is postulated that changes of its depths along the fault reflect the total amplitude of vertical movement of the blocks. Using (1) for computing the vertical gradient of change in density $\partial\sigma/\partial H$ for a definite depth range and knowing rock density σ at the upper edge of the block H_1, it is possible to compute upper mantle rock density σ_M at the depth H_2:

$$\sigma_M = \sigma + \frac{\partial\sigma}{\partial H}(H_2 - H_1). \quad (2)$$

Application of this method is illustrated in detail for part of the Sea of Okhotsk and a continental area extending several hundreds of kilometers inland. Figures 3; references 14: 12 Russian, 2 Western.
[33-5303]

UDC 551.510.4:551.521:551.588.7

INFLUENCE OF STRATOSPHERIC AEROSOLS FORMING DURING COMBUSTION OF ROCKET FUELS ON EARTH'S ALBEDO

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 23 Sep 80, after revision 19 Mar 82) pp 988-990

YUREVICH, F. B., YATSKEVICH, G. M. and CESS, R. D., Institute of Heat and Mass Uxchange imeni A. V. Lykov, Belorussian Academy of Sciences; Planetary Atmosphere Scientific Research Laboratory, University of the State of New York, United States

[Abstract] In a study by D. K. Brownlee, et al., SCIENCE, Vol 191, pp 1270-1271, 1976 it was postulated that the presently observed insigificant quantity of Al_2O_3 particles in the stratosphere is related to the operation of jet engines. It was further postulated that the flight of space vehicles can considerably increase the concentration of stratospheric Al_2O_3 aerosol and thereby lead to possible climatic changes. This possibility has been investigated by a number of authors, it being concluded, in general, that the influence of this aerosol on climate will probably be insignificant. But such a climatic forecast contains a number of uncertainties. The authors of this article have therefore sought to ascertain the role which would be played by the particle-size distribution in such a problem. In this investigation use is made of a size distribution which sets the possible upper limit of particle size. A comparison of the results of this study and data published by J. B. Pollack, et al., J. APPL. METEOROLOGY, Vol 15, pp 247-258, 1976 makes it possible to eliminate uncertainties relating to the particle-size distribution function in evaluating the influence of aerosol on climate. The investigation is limited to the influence of albedo on change in the earth's climate. It was found that an increase in the quantity of Al_2O_3 aerosol would increase the earth's albedo, which in turn would lead to an increase in the solar radiation assimilated by the planet and accordingly its cooling. The article analyzes the changes in albedo caused by aerosol. The radiation model used was described by R. D. Cess, et al., TELLUS, Vol 33, pp 444-452, 1981). It appears that the influence of stratospheric aerosol on albedo of the atmosphere-underlying surface system is virtually not dependent on the particle-size distribution function. The conclusions are evidently applicable to other types of stratospheric aerosols such as those forming during volcanic activity and droplets of sulfuric acid. Figures 1; tables 1; references 6: 2 Russian, 4 Western. [25-5303]

UDC 551.510.42:621.375.826

DETERMINING OPTICAL CHARACTERISTICS OF STRATOSPHERIC AEROSOL BY MULTIFREQUENCY LASER SOUNDING METHOD

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 5 Jan 82) pp 991-994

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[Abstract] The article is an exposition of a method for determining the spectral variation of the aerosol scattering coefficient $\beta_{sc}(\lambda)$ in the lower stratosphere on the basis of data from multifrequency laser sounding. A determination of the spectral variation $\beta_{sc}(\lambda)$ is made by the use of the inverse problems method, the same method employed for determining the microstructural parameters of the sounded aerosol. It is demonstrated here that a determination of the optical characteristics of stratospheric aerosol by a three-frequency lidar can be accomplished quite effectively. This is true both in the visible range and in the near-IR region. The use of the second harmonic of a ruby laser as the lidar quarter-wavelength makes it possible to increase the reliability of the retrieved values of the scattering (attenuation coefficient in the near-UV spectral region. Within the framework of the inverse problems method it is possible to evaluate the aerosol scattering coefficient β_{sc} for lidar wavelengths lying to the right of the maximum sounding wavelength 1.06 μm, this making possible the extrapolation of $\beta_{sc}^{*}(\lambda)$ into the IR range. Preliminary numerical experiments gave entirely acceptable results (although with transition into the IR-range there can be complications in use of the method due to increasing uncertainty with respect to the refractive index of aerosol matter). The possibility of extrapolation of the retrieved spectral variation $\beta_{sc}(\lambda)$ (and $\beta_{ex}(\lambda)$) into the IR region, where the direct measurement of optical characteristics meets with considerable technical difficulties, is the most important merit of the described method for investigating the optics of atmospheric aerosols by multifrequency laser sounding. Not only is it possible to retrieve the spectral variation of the scattering coefficient, but also any other optical characteristics of light scattering, including polarization characteristics. Figures 3; tables 1; references 8: 5 Russian, 3 Western.
[25-5303]

UDC 551.521.3

ALTITUDINAL CHANGE IN CONTINUOUS ABSORPTION IN ATMOSPHERIC TRANSPARENCY WINDOW 8-12 μm

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences) pp 995-998

TELEGIN, G. V. and FOMIN, V. V., Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences

[Abstract] The influence of molecular absorption on the formation of attenuation in the transparency window 8-12 μm is very important for practical

atmosperhic research. The purpose of this study was an examination of the behavior of continuous absorption with altiture, since in an earlier investigation (ZH. PRIKL. SPEKTROSKOPII, Vol 33, No 3, pp 513-516, 1980) the authors established a complex relationship between line shape and total and partial pressures, as well as gas temperature. The point of departure is the fact that the absorption coefficient in the wings of the H_2O lines in a H_2O-N_2 mixture consists of two parts due to H_2O-H_2O and H_2O-N_2 collisions. A detailed investigation of this fact clarified the following. In evaluations of continuous absorption in the real atmosphere it is clear that it is necessary to take into account its two parts: $\tau_{cont}(H_2O - H_2O)$ and $\tau_{cont}(H_2O - N_2)$. The spectral variation and temperature dependence of these two parts are different, and this must be taken into account in the computations. The relationship of the two parts of continuous absorption is different altitudes--in the lower layers of the atmosphere there is a predominance of $\tau_{cont}(H_2O-H_2O)$, and in the upper layers (H 5 km), vice versa. However, the principal contribution to the total optical thickness (in the model used here) is from the lower 3-km layer. Both parts of continuous absorption can be computed using a generalized spectral line contour, which makes possible a correct approximation of both the frequency variation and the temperature dependence of both parts. Figures 3; references 15: 9 Russian, 6 Western.
[25-5303]

UDC 551.524.72

VERTICAL TEMPERATURE GRADIENT IN TROPOSPHERE AND ITS RELATIONSHIP TO SURFACE TEMPERATURE ACCORDING TO EMPIRICAL DATA

Moscoq IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 17 Jun 82) pp 913-919

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[Abstract] The γ parameter (mean vertical temperature gradient or lapse rate) is an important characteristic of the earth's climate system. The difficulty in analyzing this parameter is the global nature of the mechanisms of formation of the vertical temperature gradient and the feedbacks in the earth's climate system dependent on it. The mean γ gradient in the heights of the troposphere is not constant and varies both in time and space, for example, with latitude and in the annual variation. Accordingly, the author has sought to clarify the vertical temperature gradient γ for the troposphere on the basis of observation data and parameterization of its changes with changes in the thermal regime of the earth's climate system for global (hemispherical) models. The study was based on data in the Western literature on the vertical distribution of temperature in different latitude zones of the northern hemisphere in the annual variation and in a mean annual regime. Using these data the author arrives at a γ value of 6K/km as an average for the northern hemisphere. The γ value decreases considerably from the equator to the pole. The dependence of on surface temperature T_s is determined for

both the northern hemisphere as a qholw and for different latitudes. The article gives a comparison of the results obtained using different empirical data. It was found that the γ value with a high degree of accuracy is proportional to T_s and on the average $d\gamma/dT_s = 0.04\pm0.01$ km^{-1} according to different empirical data for different latitudes in a mean annual regime and in the annual variation for the northern hemisphere as a whole. The mean zonal values $d\gamma/dT_s = 0.04\pm0.03$ km^{-1} were computed on the basis of different data in the annual variation for latitudes greater than 20°N. In the equatorial latitudes, according to different data, there is a difference even in the sign on $d\gamma/dTs$. Figures 2; tables 2; references 19: 5 Russian, 14 Western.
[25-5303]

UDC 551.521.14

COEFFICIENT OF BRIGHTNESS OF LIGHT REFLECTED BY SEMI-INFINITE MEDIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 21 Jul 80, after revision 28 Sep 82) pp 927-936

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[Abstract] The author presents the full derivation of simple approximate formulas for the brightness (luminosity) coefficient of light reflected by a semi-infinite medium with highly anisotropic scattering. Special cases are also considered, such as conservative scattering and appreciable true absorption. The formulas presented here are applicable for both simple scattering indicatrices and for indicatrices having a complex angular structure when scattering is at great angles. The accuracy of these approximations is evaluated. It is shown that the results can be used in computing the brightness coefficient of clouds of different microstructure in the visible and IR spectral regions for solar zenith angles $\leq 60°$. Figures 4; references 17: 16 Russian, 1 Western.
[25-5303]

UDC 551.510

STATISTICAL CHARACTERISTICS OF VERTICAL STRUCTURE OF BACKSCATTERING IN LOWER TROPOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 7 Dec 81, after revision 19 Jul 82) pp 937-943

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[Abstract] In the quantitative interpretation of data from single-frequency laser sounding the principal source of uncertainty is the lack of a priori

information on the lidar ratio. In fact, data on the nature of the vertical structure of the lidar ratio are virtually absent due to difficulties in simultaneous measurement of the coefficients of total scattering and backscattering. However, in order to carry out the required experimental investigations the authors have developed methods for measuring the vertical profile of the lidar ratio which are based on the use of both one and two lasers. Their first experiments revealed the presence of great variations in lidar ratio vertical profiles, indicating a significant role of the spatial distribution of such meteorological parameters as temperature and relative humidity. It was possible to ascertain the statistical characteristics of the vertical structure of the lidar ratio to altitudes of 3 km at nighttime and 1.5 km during the daytime. The investigation was based on material collected under continental conditions at a wavelength 0.69 μm during the spring and summer months of 1974-1976; the daytime and nighttime observation series consisted of 320 and 640 measurement cycles. The authors computed the mean profiles, standard deviations, autocorrelation matrices, eigenvalues and systems of eigenvectors. It was found that the use of a base system of three vectors makes it possible to approximate deviations of the lidar ratio with an accuracy to about 8%. Figures 4; tables 2; references 9: 7 Russian, 2 Western. [25-5303]

UDC 551.596.1

ATTENUATION OF INTERNAL GRAVITY WAVES IN ATMOSPHERE DUE TO GENERATION OF SECONDARY HARMONICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 10, Oct 83 (manuscript received 7 Jul 82) pp 1011-1019

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[Abstract] The author investigated the mechanism of nonlinear generation of secondary wave movement by a simple harmonic wave. This already comes into play with relatively small amplitudes when the convective instability mechanism still has not developed. The secondary wave movement removes energy and momentum from the initially propagating wave and therefore its effect on this wave is similar to the effect of viscosity and thermal conductivity. On the basis of perturbation theory the author computes the rate of dissipation, that is, the energy imparted in a unit time to the secondary current. The role of this mechanism is compared with the role of molecular and turbulent viscosity. The discussed mechanism of generation of secondary waves is only one of the elementary nonlinear mechanisms. A greater effectiveness of one elementary process in comparison with another still does not ensure a greater mean statistical effectiveness because it is unclear a prior what the relative frequency of the conditions of their formation may be. It is necessary to have a theory which would take into account all the possible nonlinear mechanisms in the presence of an adequately broad wave spectrum. Then, on the basis of empirical wave spectra it would be possible to clarify the role of any mechanism in the overall picture of nonlinear dissipation. It is concluded that for short waves the resonance pumping mechanism is more

effective than the mechanism of generation of secondary waves, whereas for long waves the latter is more effective. The resonance pumping mechanism is operative only in the presence of quite well-developed atmospheric wave action then the probability of appearance of synchronism conditions is great, whereas the generation mechanism is always operative. The qualitative picture of nonlinear decay of waves can be visualized as follows. Long-wave perturbations, propagating upward, decay, primarily generating secondary waves. However, the interactions of secondary waves generated by all other waves occur due to the resonance mechanism and create some overall effect of the turbulent viscosity type. Tables 1; references 16: 12 Russian, 4 Western.
[28-5303]

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DISTRIBUTION OF PROBABILITIES OF COMPONENTS OF VELOCITY, TEMPERATURE AND SPATIAL TEMPERATURE DIFFERENCES IN ATMOSPHERIC SURFACE LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
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[Abstract] A study was made of the distribution of probabilities of the three wind velocity components, temperature and spatial temperature differences in the surface atmospheric layer with stable and instable stratifications. In measuring the spatial temperature difference use was made of two identical sensors of tungsten wire cut into a common bridge and placed on a rotatable head which afforded a possibility for rapid change in orientation of the base and the distance between the sensors in the range from 0 to 200 cm. Two measurement regimes were used. In the first the distance between sensors successively assumed values 2, 4, 16, 64 and 128 cm with a constant height of 200 cm. For each distance measurements were made alternately for two orientations of the base (longitudinal and vertical, etc.). In the other regime the base was fixed (50 cm vertically) and the height assumed different values in the interval 1-6 m. Simultaneously with the temperature difference, an acoustic anemometer at this same height was used in measuring the longitudinal, transverse and vertical velocity components and temperature fluctuations using a resistance thermometer which was matched with the acoustic anemometer sensor. The measurements were made only in completely cloudless weather near midday and midnight with each measurement lasting about 10 minutes. There was found to be a considerable asymmetry of the distributions of probabilities of temperature and spatial temperature differences with vertical and longitudinal orientations of the base and nonequilibrium stratification. Figures 4; references 21: 14 Russian, 7 Western.
[28-5303]

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LIDAR-NEPHELOMETRIC INVESTIGATIONS OF MICROSTRUCTURE OF AEROSOL MEDIA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 10, Oct 83 (manuscript received 28 Jun 82, after revision 12 Oct 82) pp 1027-1034

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[Abstract] The article describes a method and presents the results of retrieval of the aerosol particle-size distribution ob tained by the spraying of a water-glycerin mixture. The spectra were obtained by inversion of the results of measurements of the scattering indicatrix (phase function) at the wavelength $\lambda = 0.56$ μm. At the same time measurements were made of the extinction and backscattering coefficients at a wavelength $\lambda = 0.6328$ um. The measured characteristics revealed a good agreement with the characteristics computed using the Mie theory for the retrieved particle-size distributions. The results of determination of the microphysical and optical characteristics were used in interpreting lidar investigations of the trails of water-slycerin aerosol. The experiment, which is thoroughly described, indicated that lidars in monostatic 1- and 2-frequency variants make it easy to monitor great volumes of the atmosphere due to relative simplicity of observations, but require the use of prior information on the optical and microphysical characteristics of the aerosol. The materials presented in the article include an example of a possible variant for collection of the required a priori information. Photometric and nephelometric measurements at several wavelengths afford a good possibility for checking the results of retrieval of the particle-size distribution. This checking is carried out using the following procedures: the angular characteristics of scattered radiation obtained at one wavelength are used in retrieving the size distribution by solving the pertinent inverse problem; then this distribution is used in computing some optical characteristic of the medium for the other wavelength. Figures 3; references 7: Russian. [28-5303]

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SPECTRAL MEASUREMENTS OF TRACE GAS COMPONENTS IN ANTARCTIC ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 9, Sep 83 (manuscript received 27 Jul 82) pp 899-901

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[Abstract] Measurements of the total atmospheric content of CO, CH_4 and N_2O were carried out at Mirnyy station in Antarctica in January-February 1982. The climatic conditions at Mirnyy in summer are favorable for such investigations (low wind velocities, low atmospheric moisture content, abundance of sunshine). During the year the total sunshine is almost twice as great as in the Arctic. Measurements were with a field spectral complex described earlier in the literature. The content of each investigated gas was determinted on the basis of the absorption of solar radiation by the entire thickness of the atmosphere in definite parts of the spectrum. All observations were made on clear sunny days with a meteorological range of visibility $S_M \geqslant 20$ km. The air temperature during measurements was in the range -7 to +3°C and the absolute humidity was from 2 to 7 gPa. The plotted data reveal a virtually complete agreement with the results obtained in 1978. This is evidence of the stability of manifestation of effects associated with these trace components discussed in published materials. The measured total CO contents probably correspond to the summer-autumn seasonal variation of this component in Antarctica. Figures 1; references 5: 4 Russian, 1 Western. [25-5303]

SCO: 1865

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